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TERMINAL FORECAST REFERENCE NOTEBOOK(TFRN) ZARAGOZA AB, SPAIN A--ETC(U

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DTIC ACCESSION NUMBER

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TERMINAL FORECAST REFERENCE NOTEBOOK

FOR

ZARAGOZA AB, SPAIN

AND

BARDENAS REALES GUNNERY RANGE, SPAIN

PUBLISHED BY:
DETACHMENT 16
31ST WEATHER SQUADRON
2ND WEATHER WING (MAC)
2 MARCH 1981

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This technical report has been reviewed and is approved for publication.

JOHN F. PHILLIPS, MAJOR, USAF
PUBLIC AFFAIRS OFFICER

FOR THE COMMANDER

MICHAEL G. OLIVIER, MAJOR, USAF
CHIEF, SCIENTIFIC SERVICES BRANCH

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CLIMATOLOGY
SPAIN
METEOROLOGICAL INSTRUMENTATION

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This publication provides guidelines for forecasting weather at Zaragoza AB, Spain and Bardenas Reales Gunnery Range, Spain. Included are the local topography, meteorological instrumentation, climatology, custumer identified operation limitations, and seasonal weather problems.

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TABLE OF CONTENTS

TITLE	PAGE

SECTION I

LOCATION TOPOGRAPHY AND INSTRUMENTATION

THE EBRO RIVER GEOGRAPHY AND TOPOGRAPHY

The Ebro River is the longest river in Spain and extends from headwaters approximately 40NM South of the northern coastal city of Bilbao to nearly 200NM southward to the Mediterranean coastal city of Tortosa.

The Ebro River Basin is triangular in form with the apex at the headwaters. The Northeast boundary of the basin is formed by the Pyrenees Mountains, which form a natural boundary between France and Spain, and by the Cantabrian Mountains, a western extension of the Pyrenees. The highest peaks, above 10,000 feet, are located approximately 80NM northwest of Zaragoza AB. A second area of high peaks above 8,000 feet are found about 200NM northwest of Zaragoza. Average elevations between these two areas are 3,000 to 4,000 feet with numerous peaks in excess of 4,000 feet. This topography effectively restricts low level maritime influences from the North Atlantic to the northern slopes of the mountains.

The Iberian Mountain Range and associated extensions form the southwestern limit of the Ebro River Valley basin, and the northeast boundary of the Central Plateau. Average terrain elevation is 2,500 feet to 3,500 feet, with numerous peaks in excess of 6,000 feet. The highest peak, Moncayo at 7,598 feet, lies 37NM northwest of Zaragoza Air Base.

Closing the triangle along the Mediterranean coast is the Catalonian Mountain Range with average elevation of 2,000 feet to 3,000 feet and numerous peaks in excess of 3,500 feet. The Ebro River flows through these mountains in a narrow valley which is 5NM wide, pinched by highlands of greater than 1,000 feet elevation on both sides.

In the Ebro basin, there are numerous areas of elevation of 2,000 feet to 3,000 feet. Those of importance to Zaragoza are the Sierra de Alcubirra, approximately 25NM east northeast of Zaragoza (elevation of 1,000 to 2,000 feet above the surrounding basin) and an extension of the Iberian Mountain Range, approximately 1,000 feet above the valley floor, reaching northward to within 10NM of Zaragoza.

In the Bardenas Reales Gunnery Range area a highland of interest is an area of approximately 1,000 feet elevation above the surrounding terrain and located 12NM southwest of the Range Weather Observing site. The range is in a small basin, with the surrounding terrain being 300 to 500 feet higher in elevation than the range.

The only body of water near Zaragoza Air Base and Bardenas Reales Gunnery Range is the Ebro River. The main channel passes within 8NM to the southwest of Bardenas and within 5NM to the northwest of Zaragoza Air Base. Extensive irrigation, both by flooding and by aspiration, provide additional moisture sources in the Ebro Valley.

Figure 1 shows the overall topography of the forecasting areas of interest.

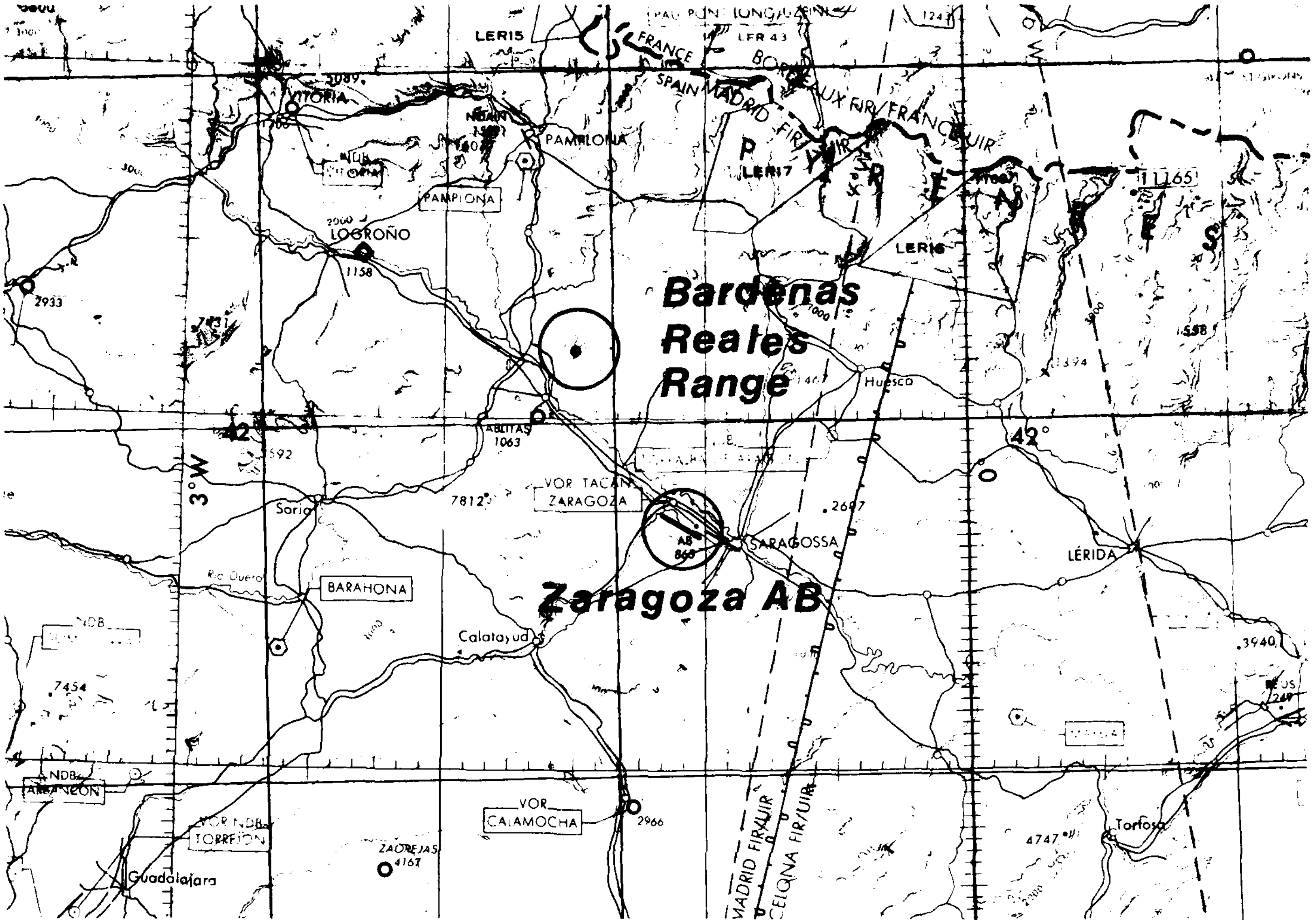


FIG 1 - Topography of Forecasting Areas of Interest

ZARAGOZA AIR BASE, SPAIN

Zaragoza Air Base is located at 41°40' North latitude and 01°02' West longitude Field elevation is 863 feet above mean sea level. It is situated midway in the Ebro Valley, approximately 10NM Northwest of Zaragoza, a city with a population of over 500,000.

The base lies in an area of generally smooth terrain which slopes rapidly upward to a plateau with an elevation of 1,500 feet within 5NM to the southwest of the base.

The main channel of the Ebro river flows to within 5 nautical miles of the base. Forming the northwest perimeter of the base is the Canal Imperial de Aragon, which provides water for the extensive irrigation and flooding to farmland between the canal and the Ebro river. There are numerous projects of irrigation by aspiration in the vicinity of the base, and more are planned.

The topography of the Ebro Valley is conducive to fall winds similar to the "mistral" of the Rhine Valley. Since Mount Moncayo is 37 nautical miles northwest of Zaragoza and its location also restricts the entry and exit into the valley, a Venturi effect accents the wind in the Zaragoza area. Winds above 35 knots are common in all seasons of the year. With the valley closed to the southwest, cold air drainage from surrounding highlands produces a cold pocket of air in the valley. The accumulation of cold air in the valley is accompanied during winter months by dense, persistant fog. It is not uncommon to have visibility of less than 1/2 mile for periods of over two to three days.

Figure 2 shows an expanded view of the Zaragoza Air Base forecast area of responsibility.

Figure 3 shows weather instrumentation at the base.

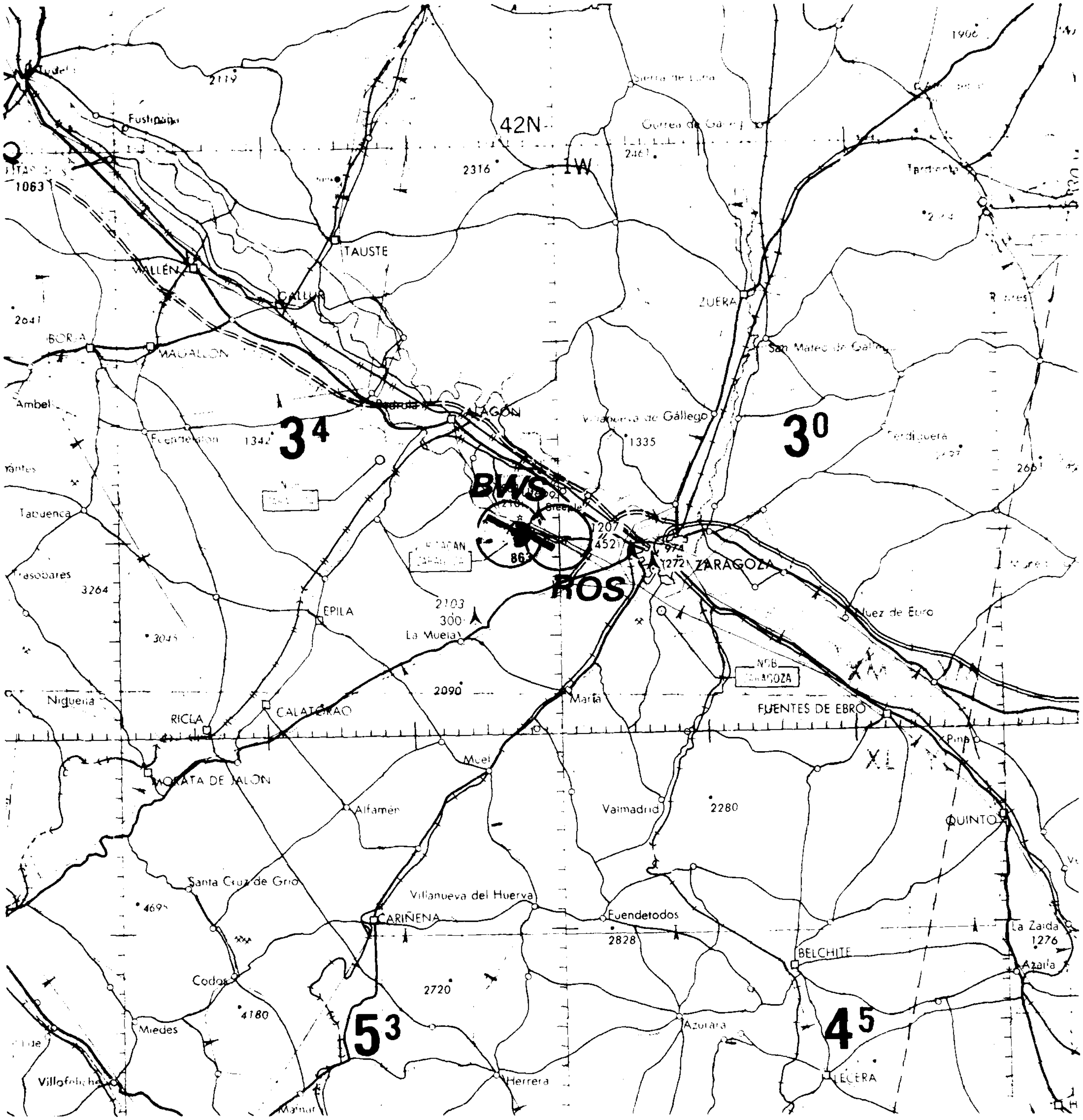


Fig 2 - Zaragoza Air Base Forecast Area of Responsibility

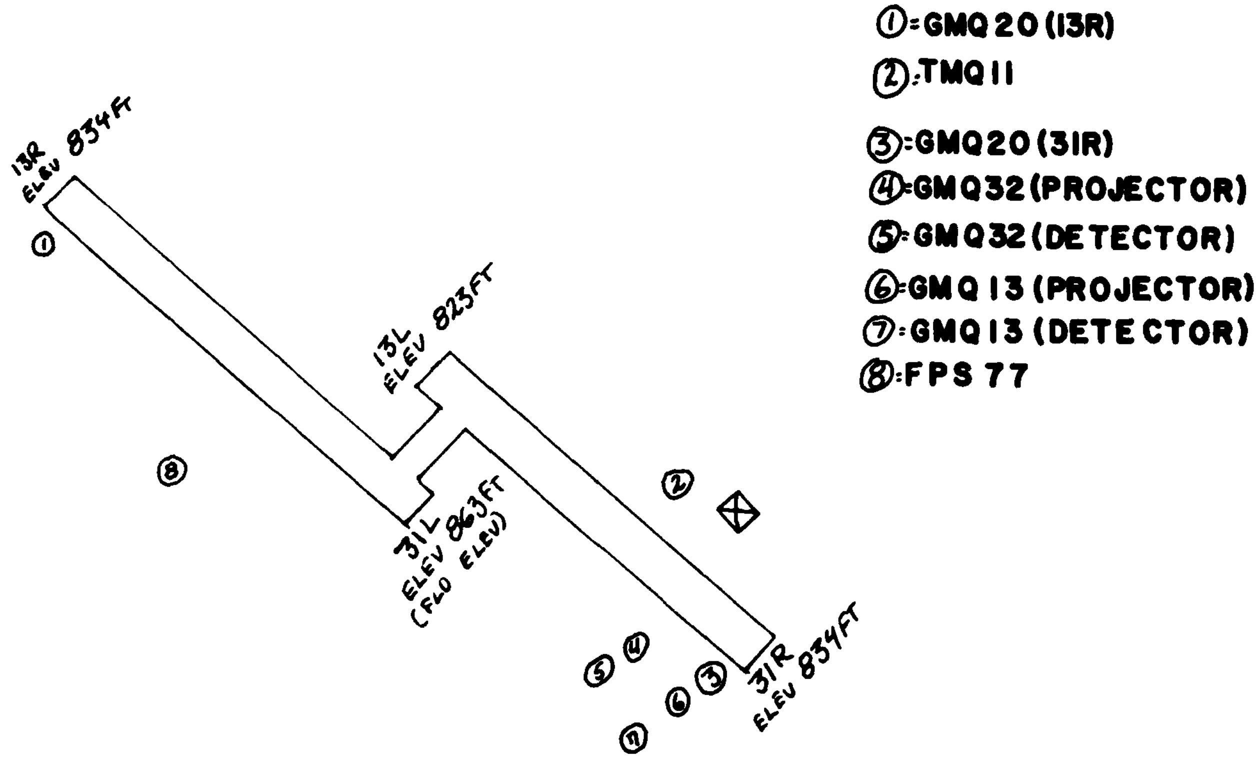


Fig 3 - Weather Instrumentation, Zaragoza Air Base

BARDENAS REALES GUNNERY RANGE, TUDELA SPAIN

With the observing site at 41°12' North latitude 01°27' West longitude, the elevation of the observing site is 997 feet above mean sea level. It lies approximately 10 nautical miles northwest of Tudela, Spain.

Bardenas Reales Range is located in a small basin with the surrounding terrain 300 to 500 feet above the basin floor. There are numerous mesas in the basin reaching 200 to 300 feet above the station elevation.

Except for the Ebro River, which flows to within 8 nautical miles to the southwest of Bardenas Reales, there is no major body of water, or moisture source. However, a large irrigation project in the area is nearing completion and will, when in use, provide a moisture source to the area.

Instrumentation is all located in the vicinity of the observation site and consists of an AN/GMQ13, Rotating Beam Ceilometer, with an 800 foot baseline, and a TMQ-15, Tactical Wind Set, which is scheduled to be upgraded to an AN/GMQ20, Wind Set. A psychrometer and aspirator set is used to measure temperatures.

The topography of the Ebro valley provides Bardenas Reales Range with similar conditions to Zaragoza Air Base. Strong "mistral" type of winds are common. As the valley is restricted downstream, the wind does not usually reach the magnitude of the winds a Zaragoza Air Base. Fog, due to the difference in elevation between Zaragoza and Bardenas Reales, is slightly less persistent. Other patterns induced by topography include strong southwest winds, accented by restrictions produced by Mount Moncayo Mountain, and advected low clouds from the northwest.

Figure 4 shows an expanded view of the Bardenas Reales Gunnery Range forecast area.

Figure 5 shows weather instrumentation at the range.

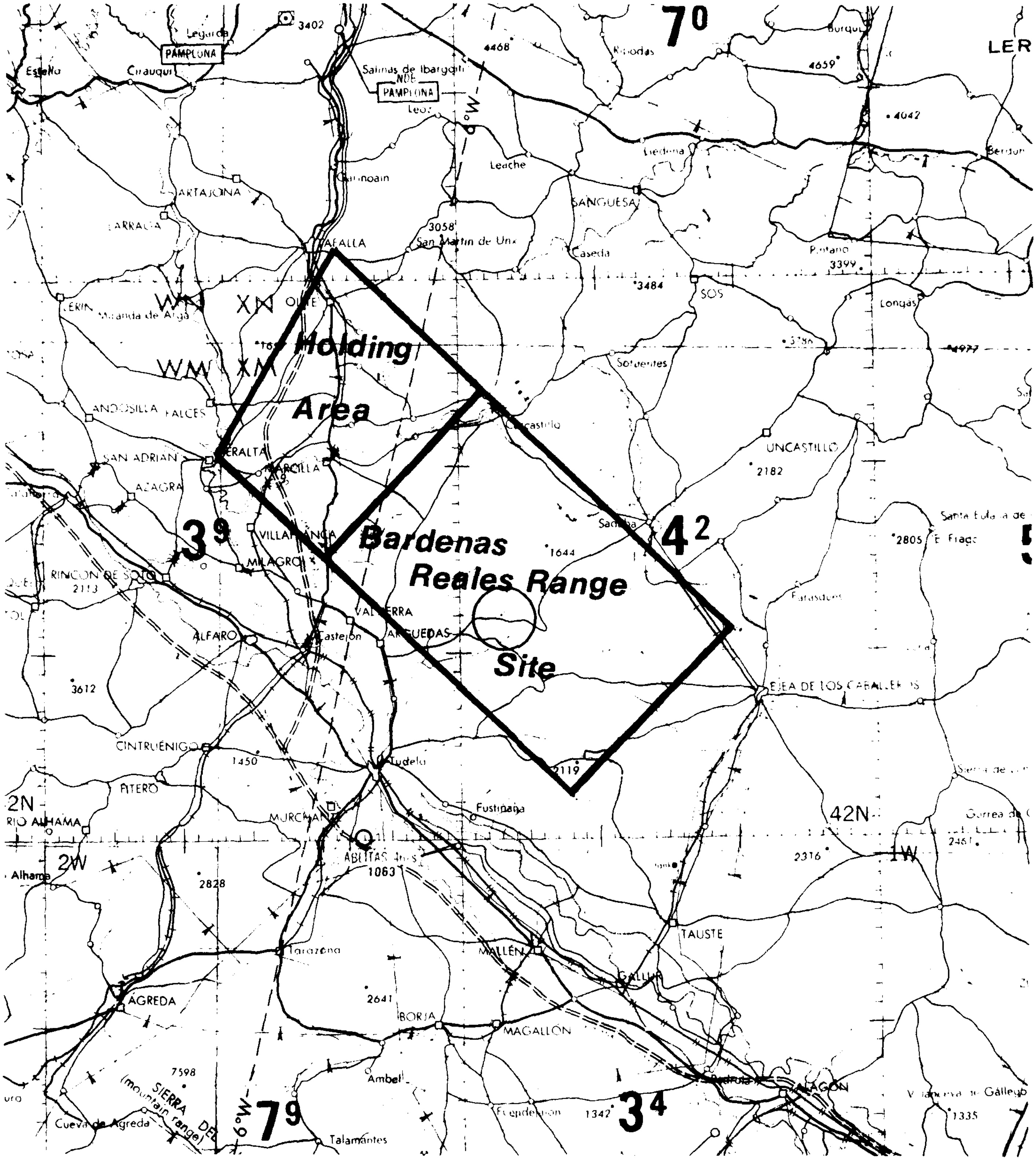


Fig 4 - Bardenas Reales Aircraft Gunnery Range Forecast Area

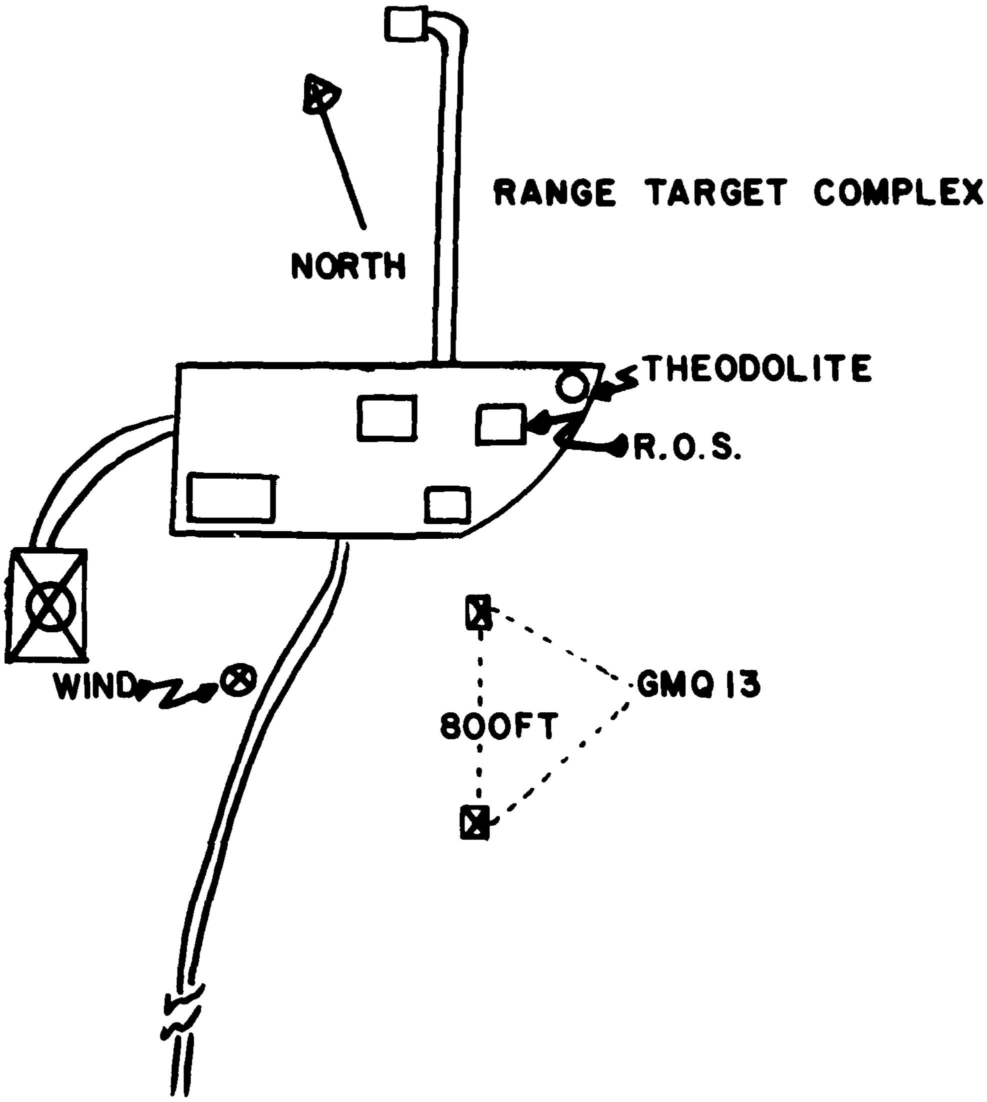


Fig 5 - Weather Intrumentation, Bardenas Reales Aircraft Gunnery Range

SECTION II

CLIMATIC AIDS

ZARAGOZA AIR BASE, SPAIN

Climatic aids for Zaragoza Air Base were extracted from the Revised Uniform Summary of Surface Weather Observations (RUSSWO) printed on 24 September 1974. The period of record was July 1957 through December 1972 for hourly observations and July 1957 through April 1967 for daily observations.

During the period April 1967 through 14 November 1979, Surface Observations were provided by Spanish Air Force Weather Observers. A Limited RUSSWO, based on these observations, is maintained in the files. Due to the differences in reporting techniques, these observations, with the exception of the absolute maximum and minimum temperatures, 24 hour maximum and monthly total precipitation, and monthly peak wind values, were excluded from the samples.

Records currently available do not reflect the maximum and minimum temperature information during the period 1965 to 1972. However, some information was available and assumed correct when the previous TFRN was completed in 1974. Only departures from the mean (higher maximum and/or lower minimums) were adjusted for this TFRN revision.

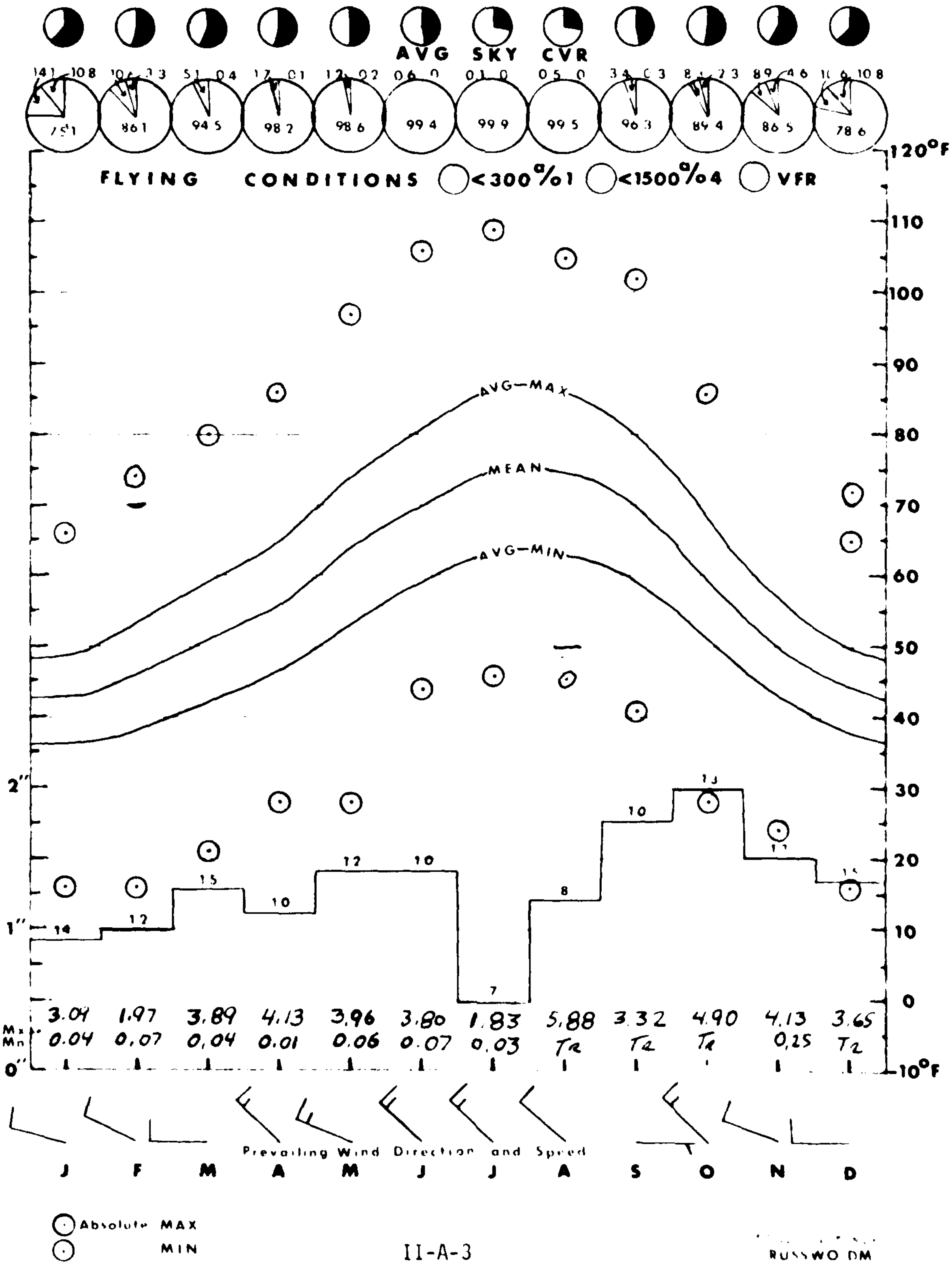
Critical weather elements include strong winds, and ceiling/visibility below 300 feet/1.0NM, 200 feet/0.5NM.

NOTE: The Revised Uniform Summary of Surface Weather Observations (RUSSWO) and the Wind Stratified Conditional Climatology Tables (WSCC) are maintained at the Forecast Section. They include USAF Based data and Spanish Based data in separate documents.

CLIMOGRAPH

ZARAGOZA AB, SPAIN

1957 to 1979



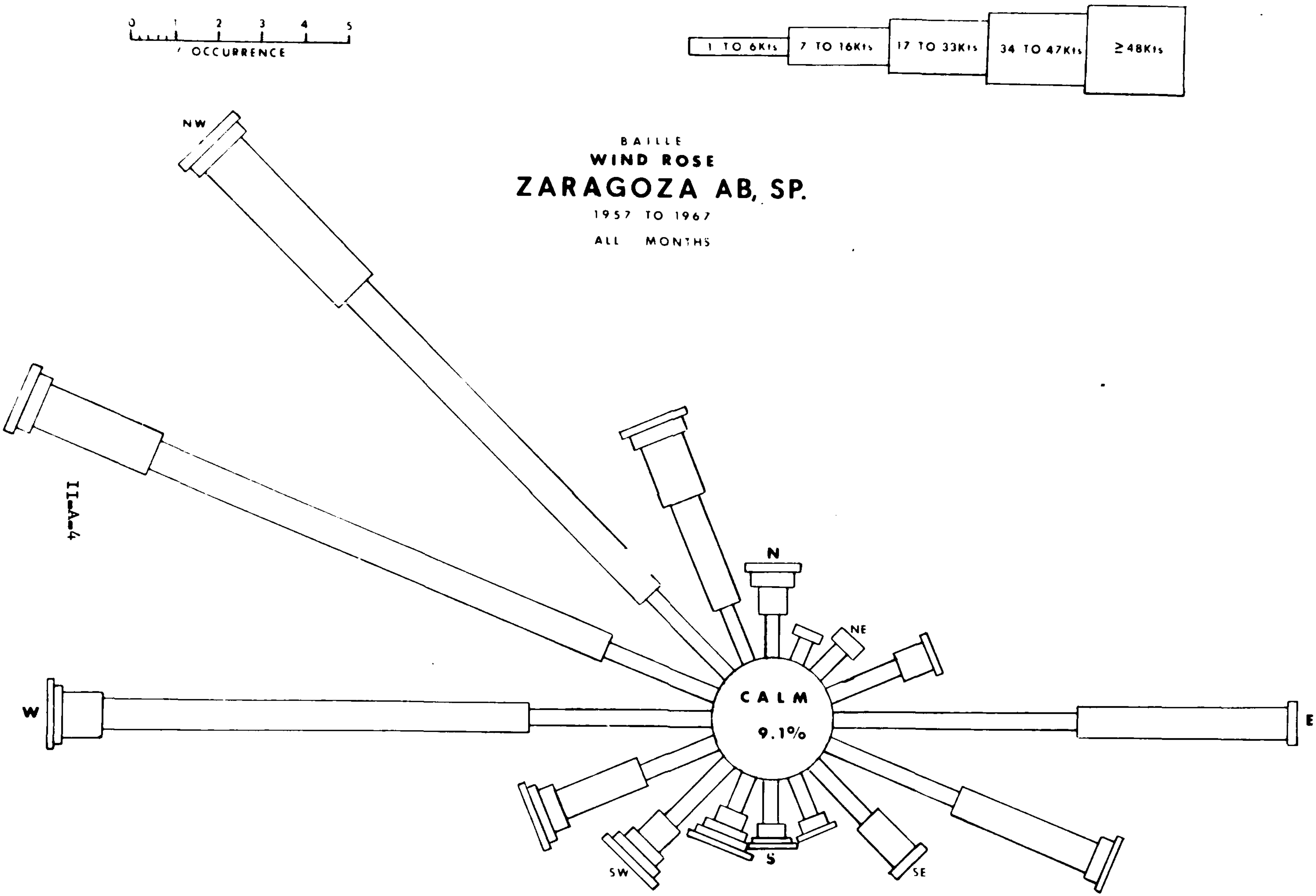
BAILLE

WIND ROSE

ZARAGOZA AB, SP.

1957 TO 1967

ALL MONTHS

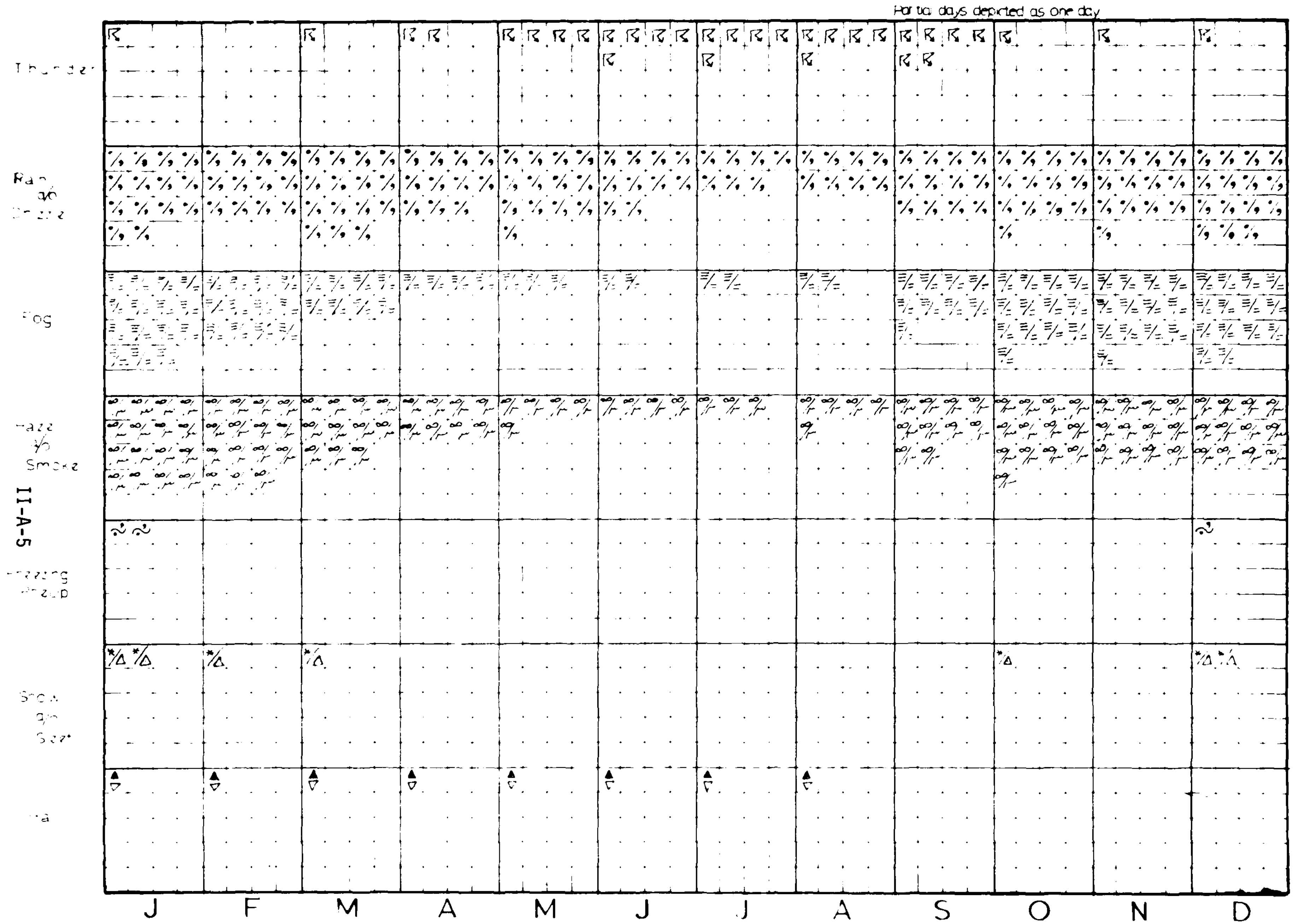


RUSSWO/DM

AVERAGE NUMBER OF DAYS PER
MONTH OF INDICATED WEATHER

ZARAGOZA AB, SP.

1957 to 1967

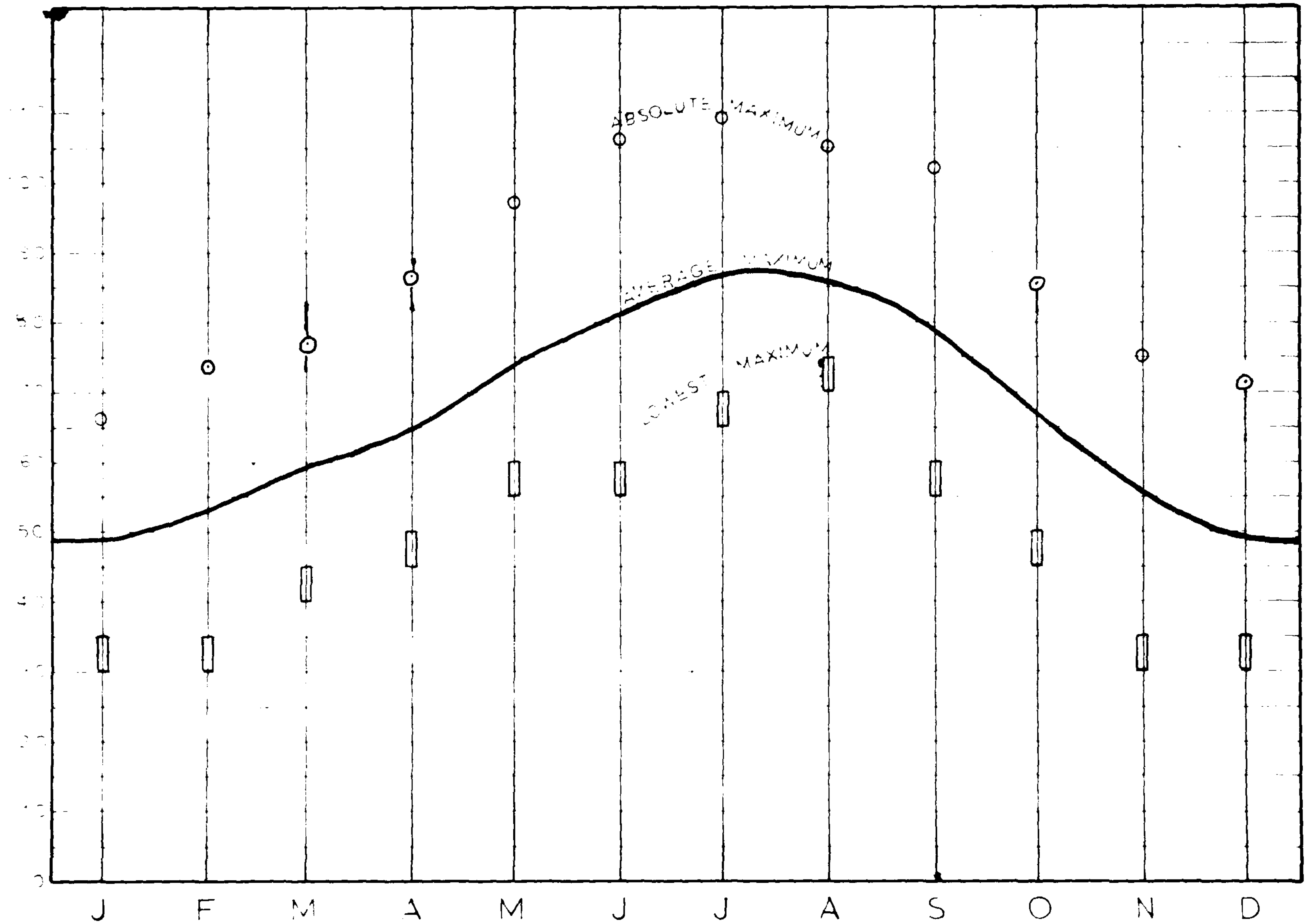


MAXIMUM TEMPERATURE DATA

ZARAGOZA AB, SP.

1957 to 1979

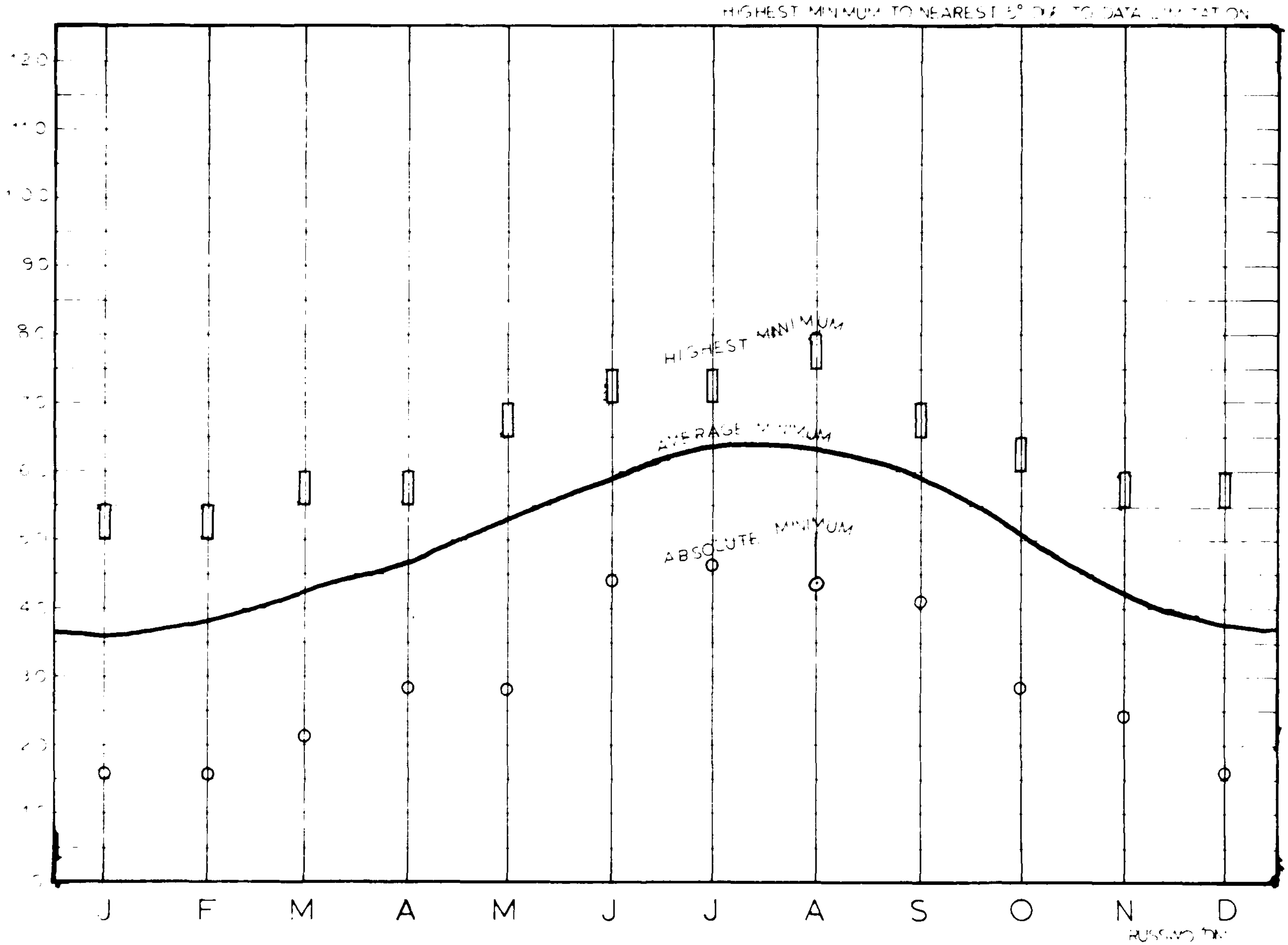
Lowest Maximum to Nearest 5° Due to Data Limitations



MINIMUM TEMPERATURE DATA

ZARAGOZA AB, SP.

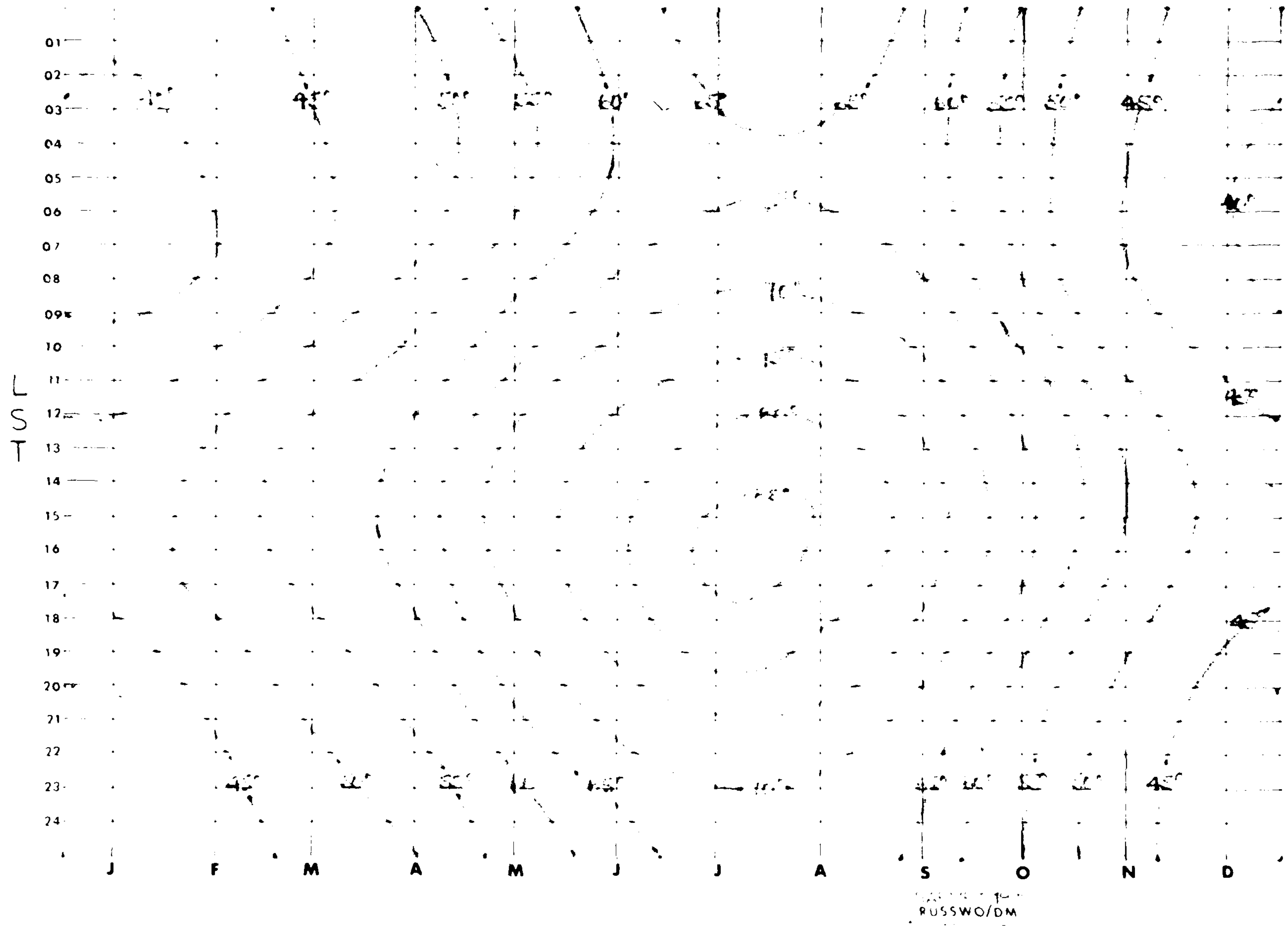
1957 to 1979



AVERAGE TEMPERATURE BY HOUR BY MONTH

ZARAGOZA AB, SPAIN

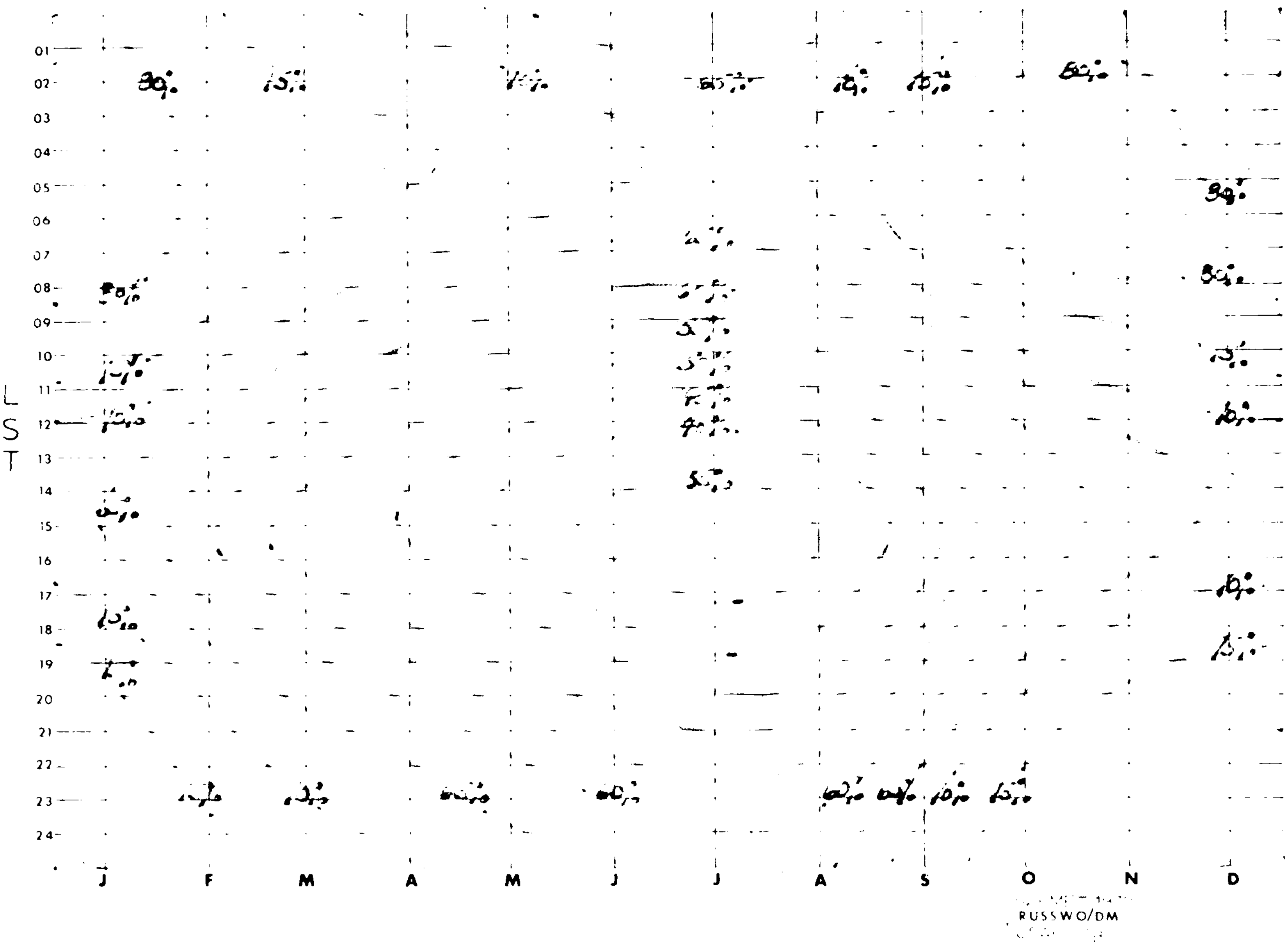
1957-1967



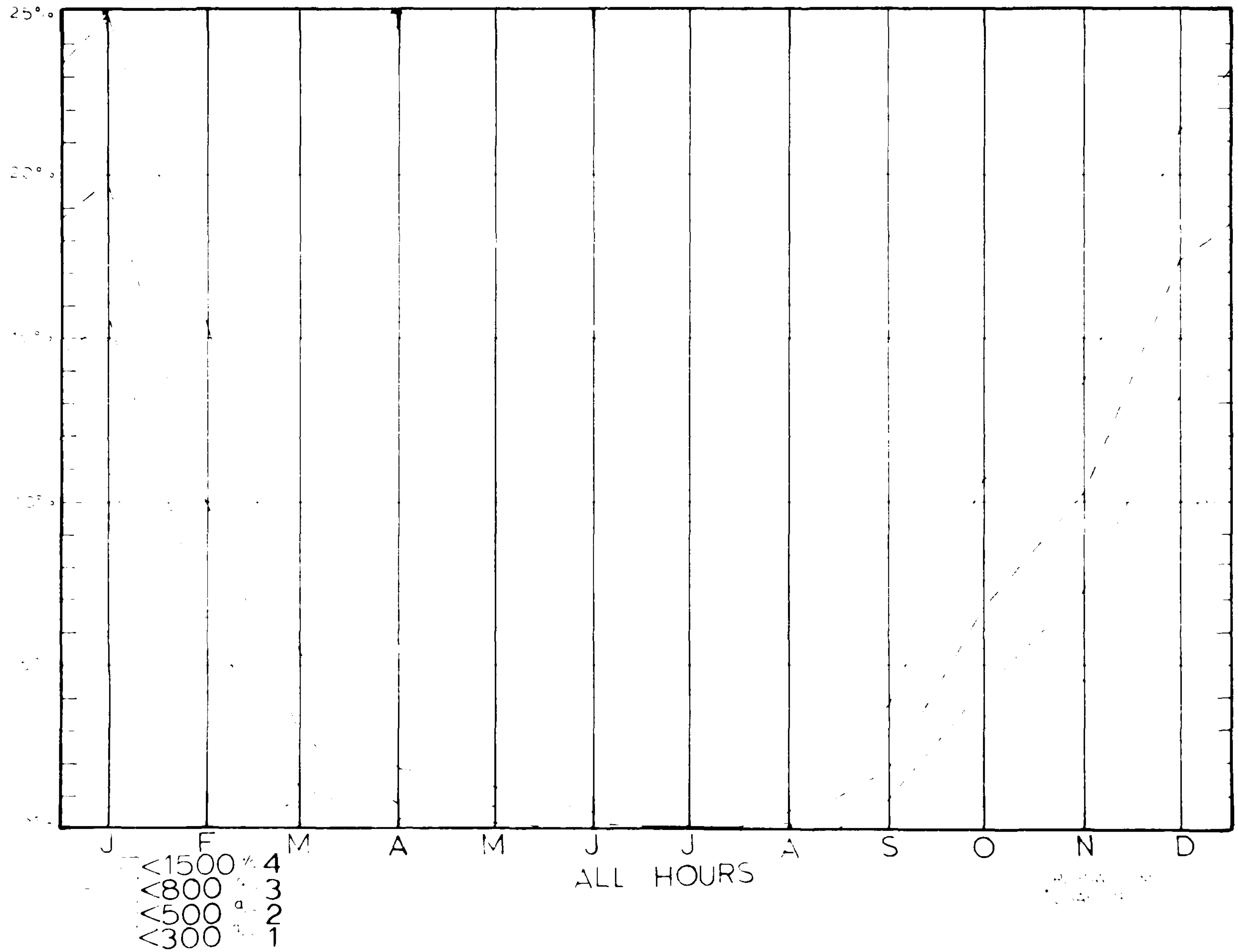
AVERAGE HUMIDTY BY HOUR BY MONTH

ZARAGOZA AB, SPAIN

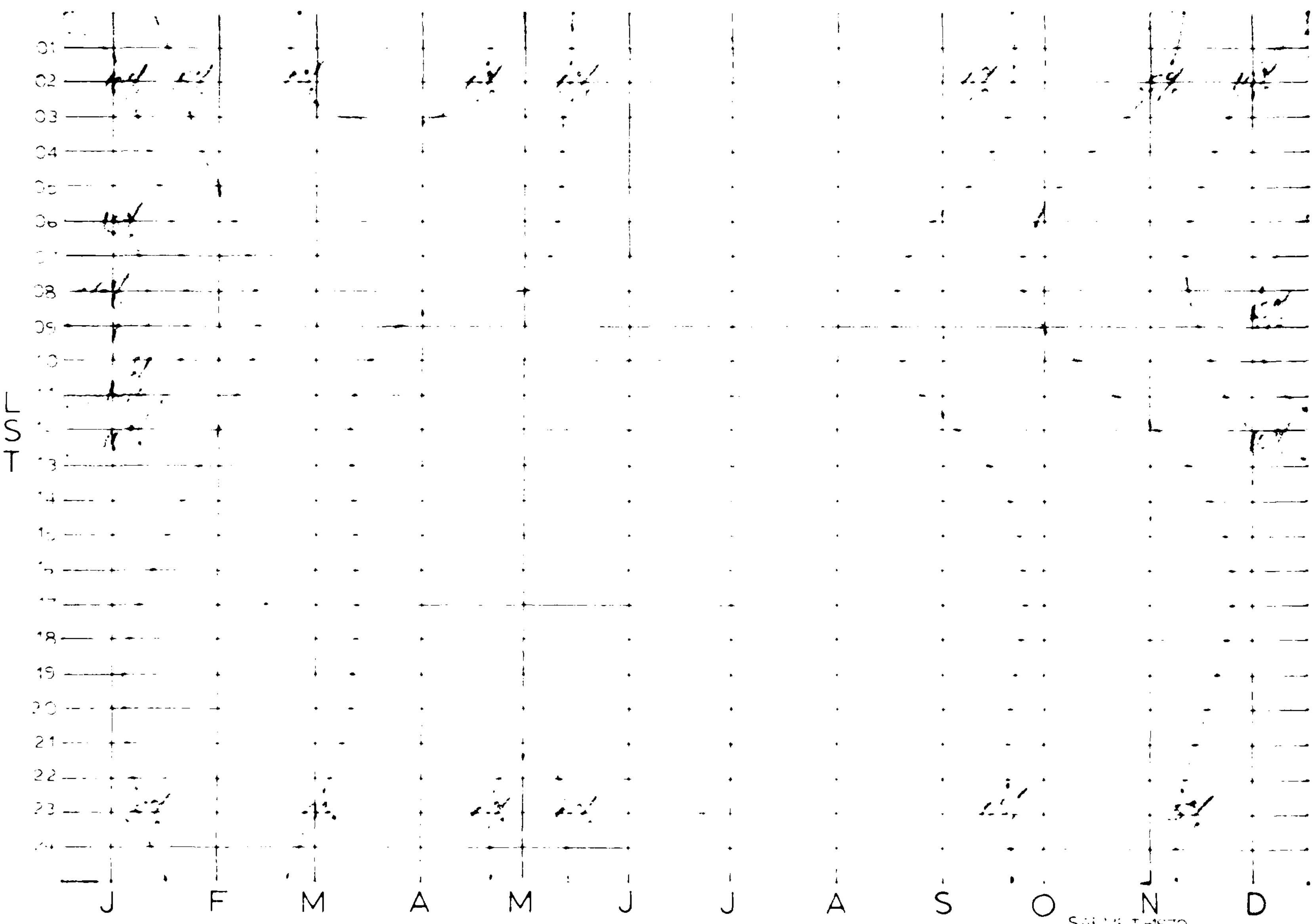
1957 - 1967



ZARAGOZA AB
FLYING CONDITIONS

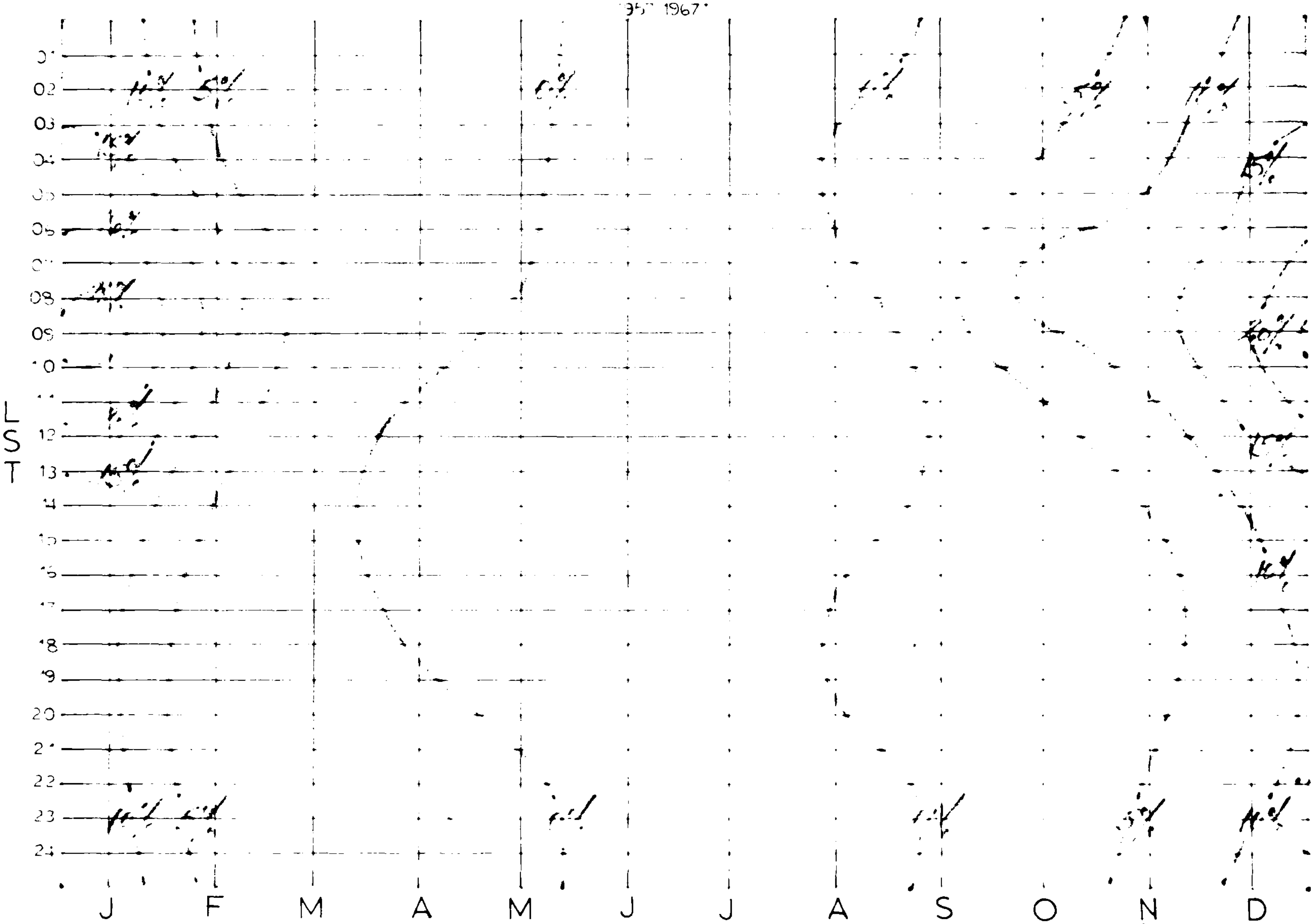


%OF TIME <300/1
ZARAGOZA AB



USAFE CAT I
BY MONTH, BY HOUR

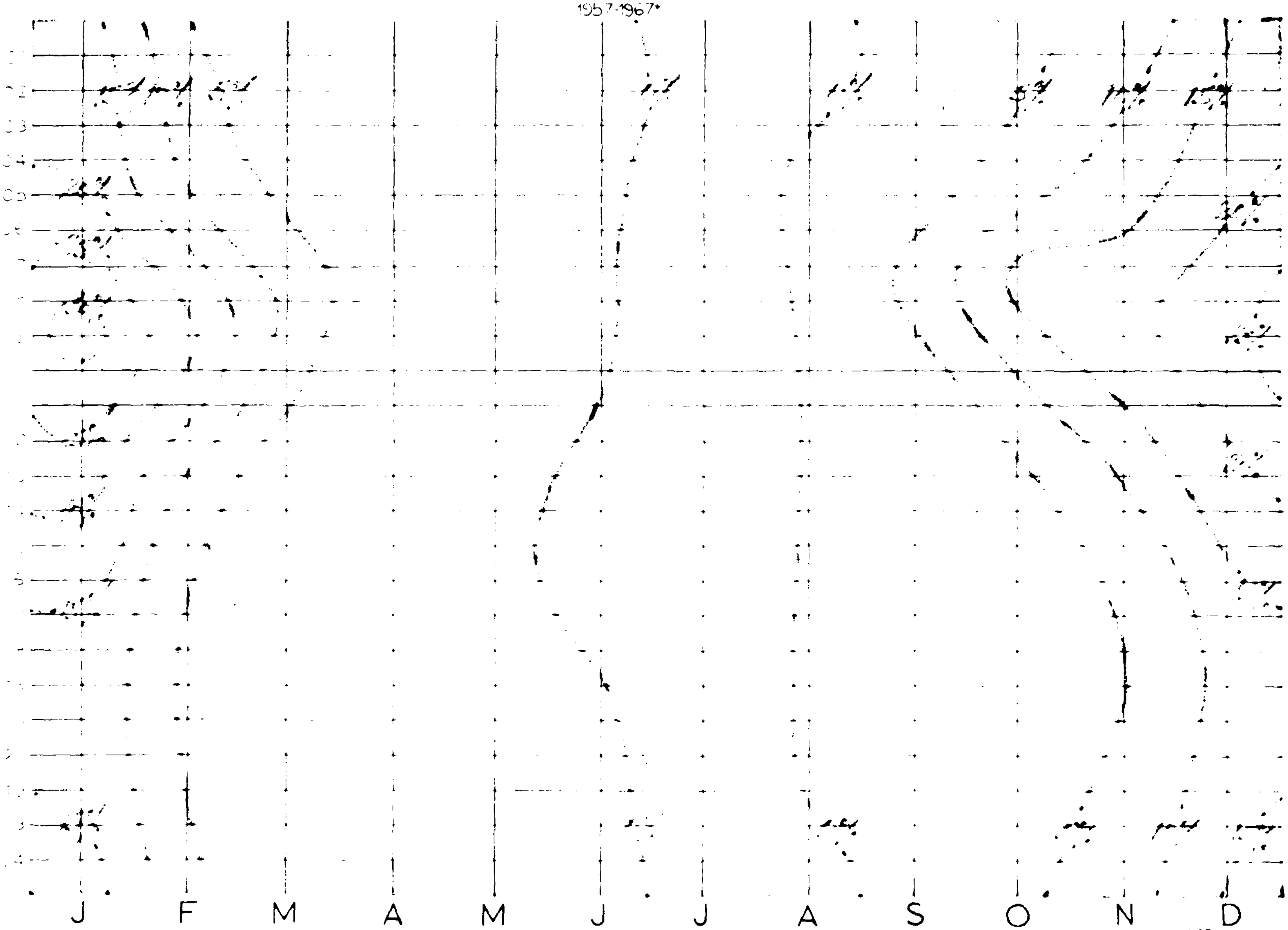
%OF TIME <500 a/2
ZARAGOZA AB



USAFE CAT II

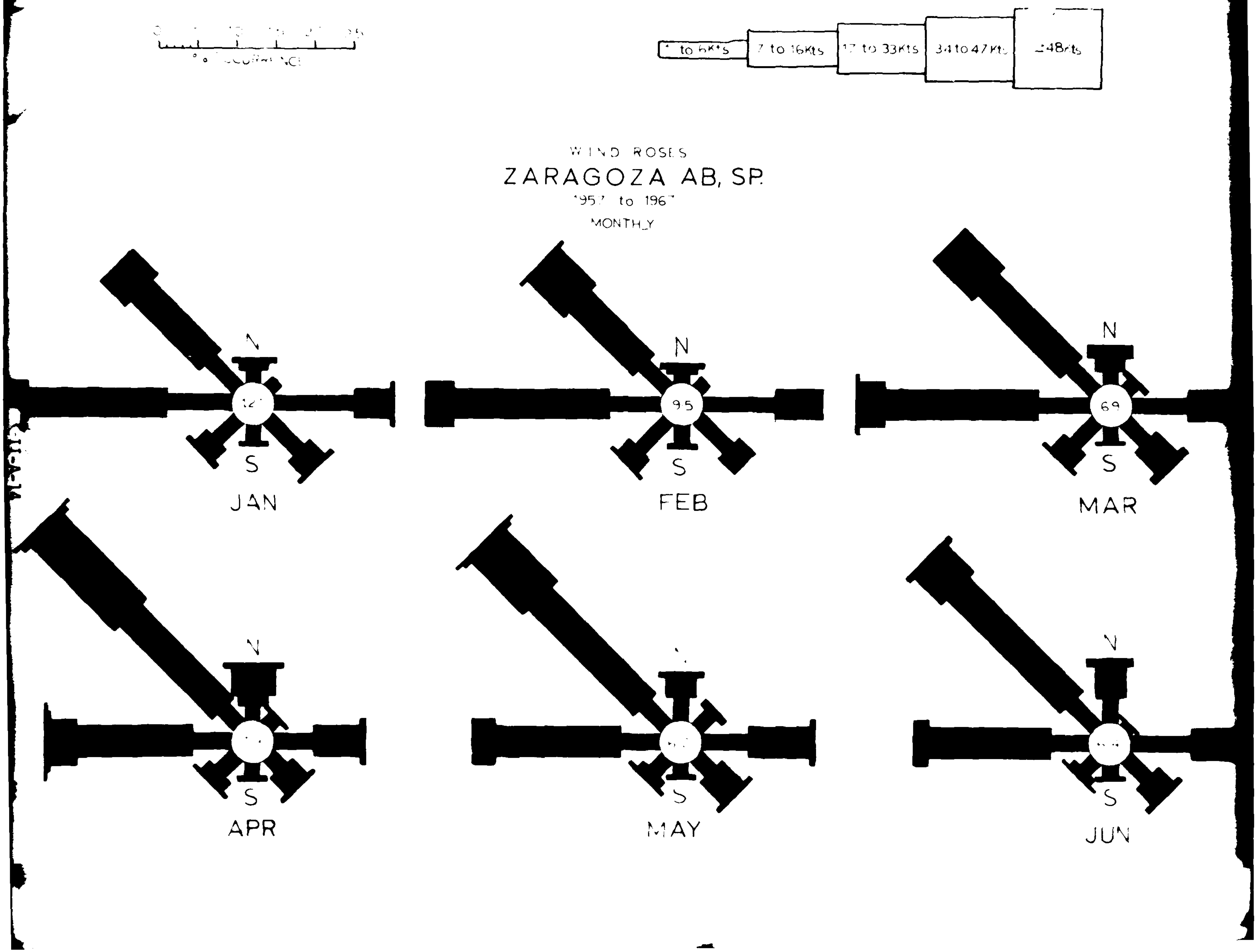
BY MONTH, BY HOUR

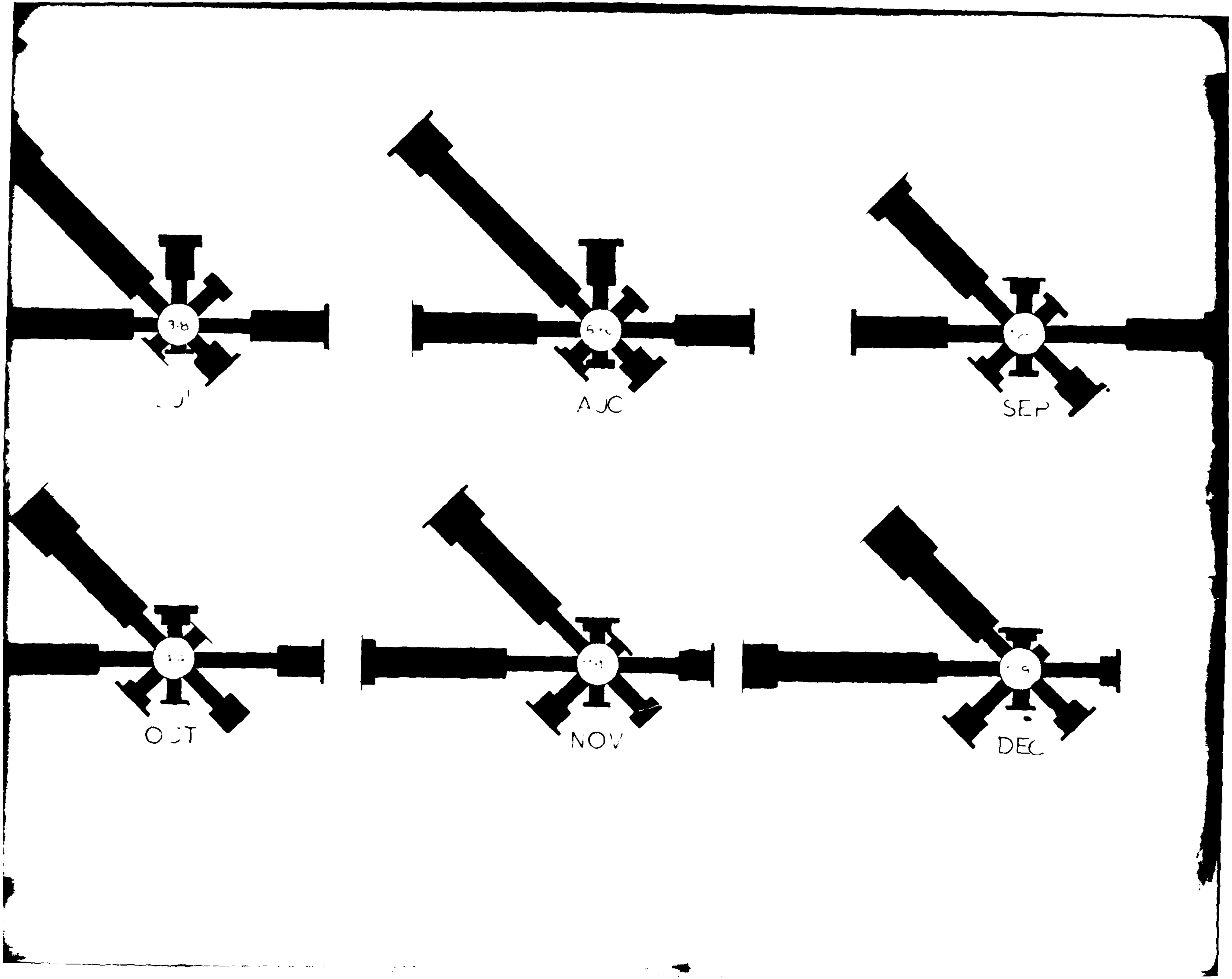
% OF TIME <800 a/o 3
ZARAGOZA AB



USAFE CAT III

BY THE MONTH BY HOUR


WIND ROSES
ZARAGOZA AB, SP.
1957 to 1967
MONTHLY
% OCCURRENCE
1 to 6Kts
7 to 16Kts
17 to 33Kts
34 to 47Kts
≥48Kts
N
S
95
69
JAN
FEB
MAR
APR
MAY
JUN



3.8
AUG
SEP
OCT
NOV
DEC

BARDENAS REALES GUNNERY RANGE, TUDELA SPAIN

Climatic Aids for Bardenas Reales Gunnery Range were extracted from the Revised Uniform Summary of Surface Weather Observations (RUSSWO) printed in 30 June 1975. The period of record was January 1970 and March 1970 through May 1975. During this lapse of time, there were numerous periods when data was not available.

Due to the small sample, this aid should be used as "trends" and not as climatological basis. This is especially true during June and July, when the range was normally closed for periods of approximately 30 days, each year.

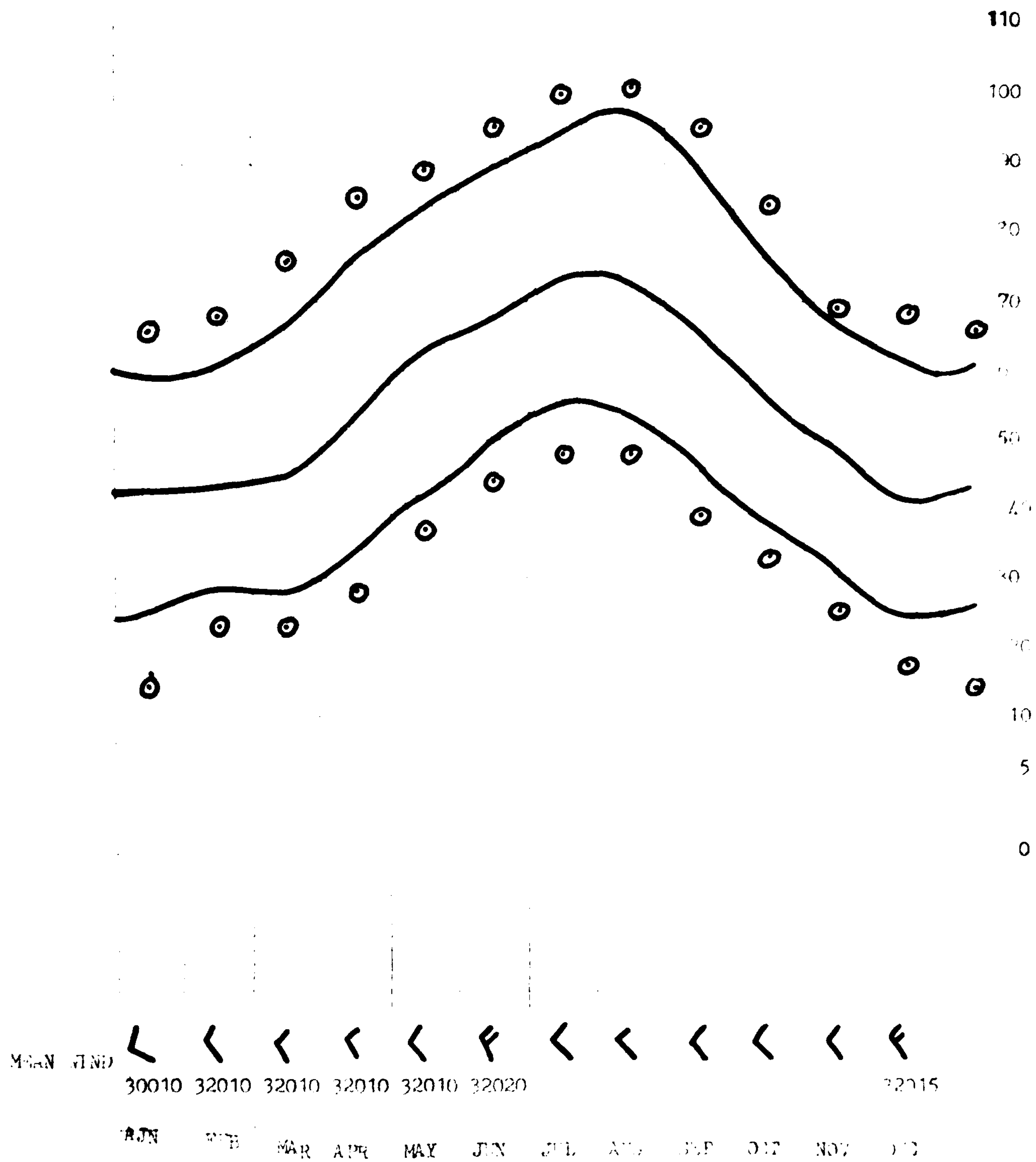
There was no record maintained on precipitation amounts.

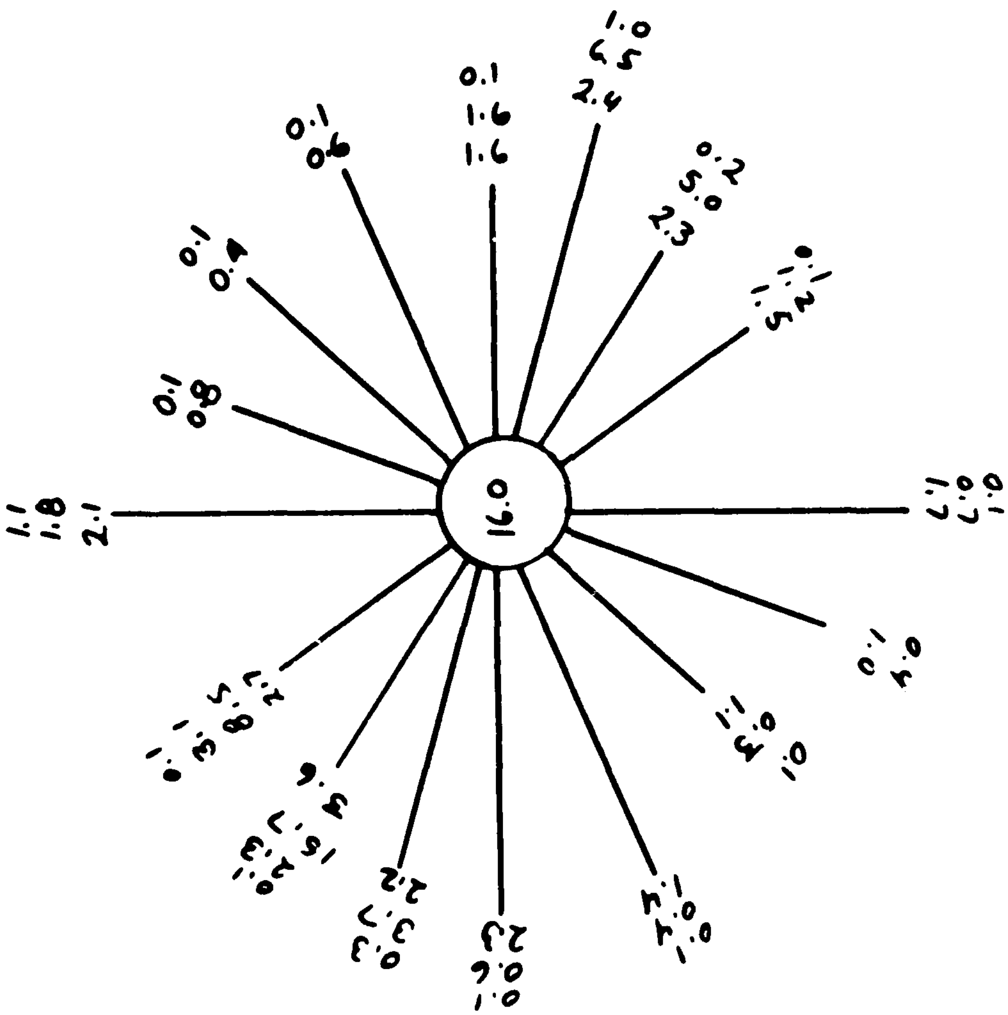
The only critical weather elements are ceilings below 3000 feet, and visibility less than 3.0NM (these are the range minimums), thunderstorms in the range complex, and surface winds in excess of 50 knots.

NOTE: The Revised Uniform Summary of Surface Weather Observations (RUSSWO) and the Wind Stratified Conditional Climatology Tables (WSCC) for Bardenas Reales Aircraft Gunnery Range (USAF Based Data) are maintained at the Forecast Section.

CLIMOGRAM FOR BARDENAS REALES GUNNERY RANGE

SKY COVER:	.64	.59	.59	.61	.61	.51	.36	.32	.46	.50	.56	.56
≥ 3000/3.0	[illegible]	93.7	93.4	98.4	96.1	[illegible]	99.7	[illegible]	94.3	[illegible]	[illegible]	[illegible]

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1.6
1.6
1.0
4.5
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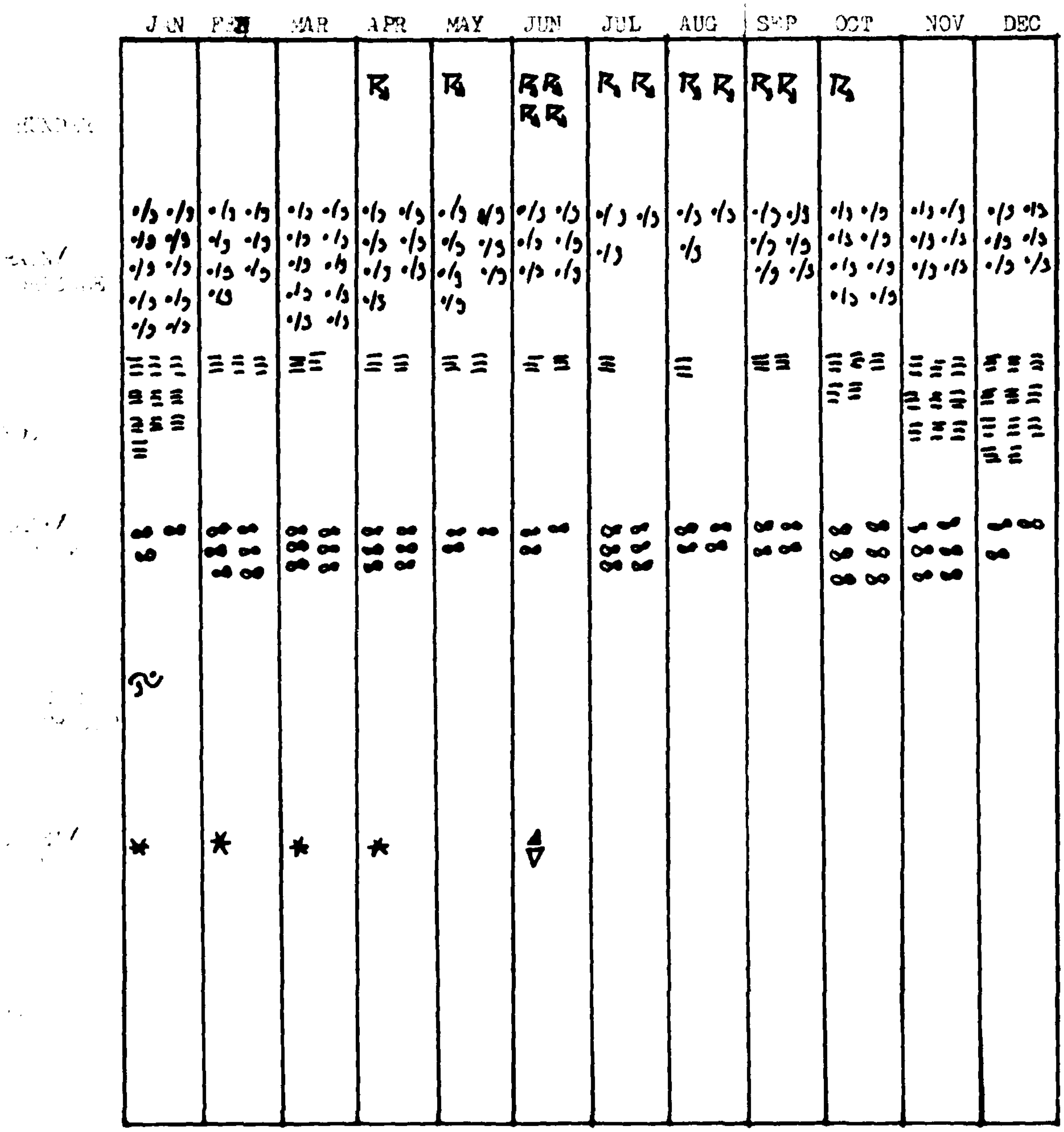
5.0
2.3
0.1
0.6
0.1
0.4
0.1
0.8
1.1
1.8
2.1

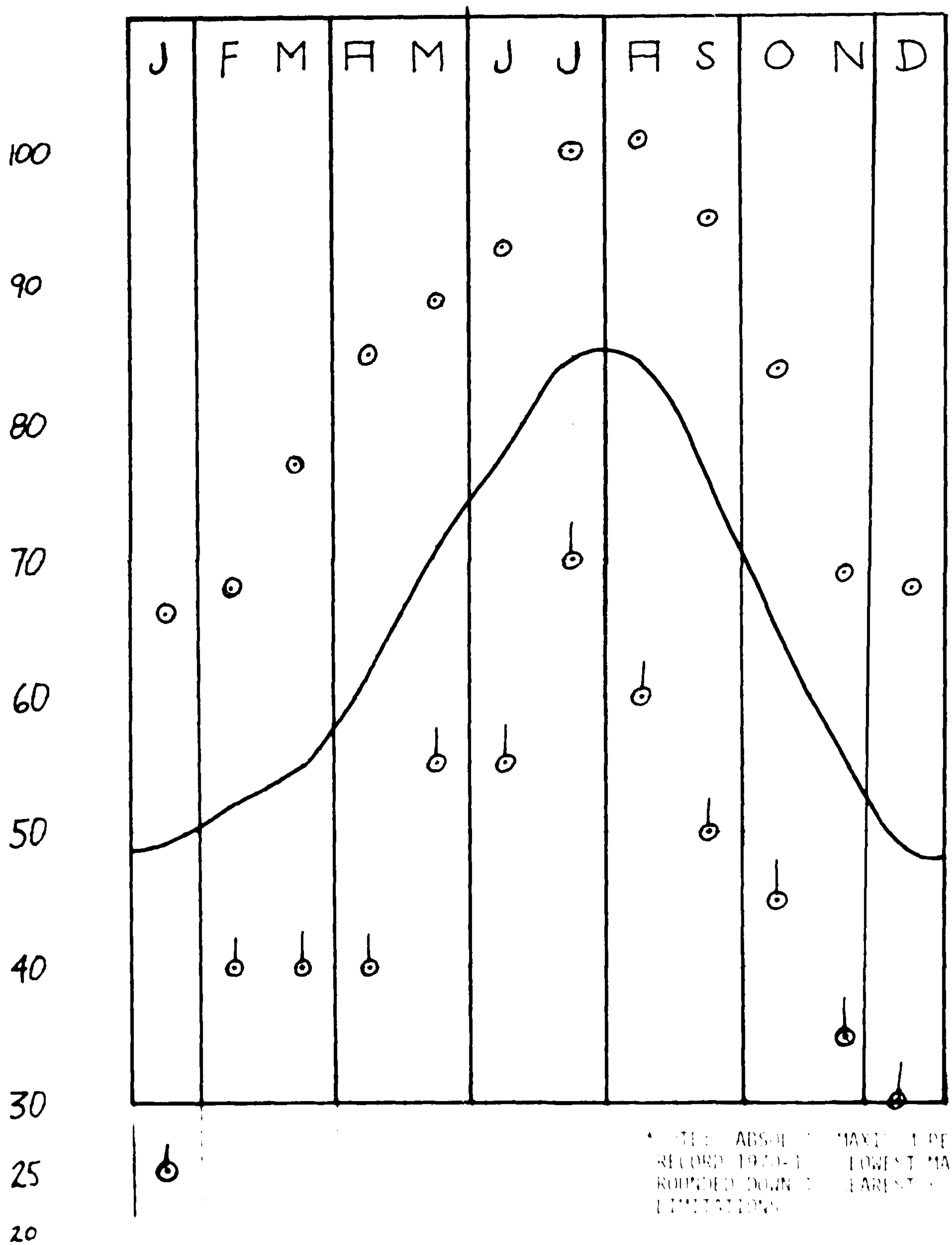
BARDENAS REALES AIRCRAFT

GUNNERY RANGE - CLIMATOLOGY



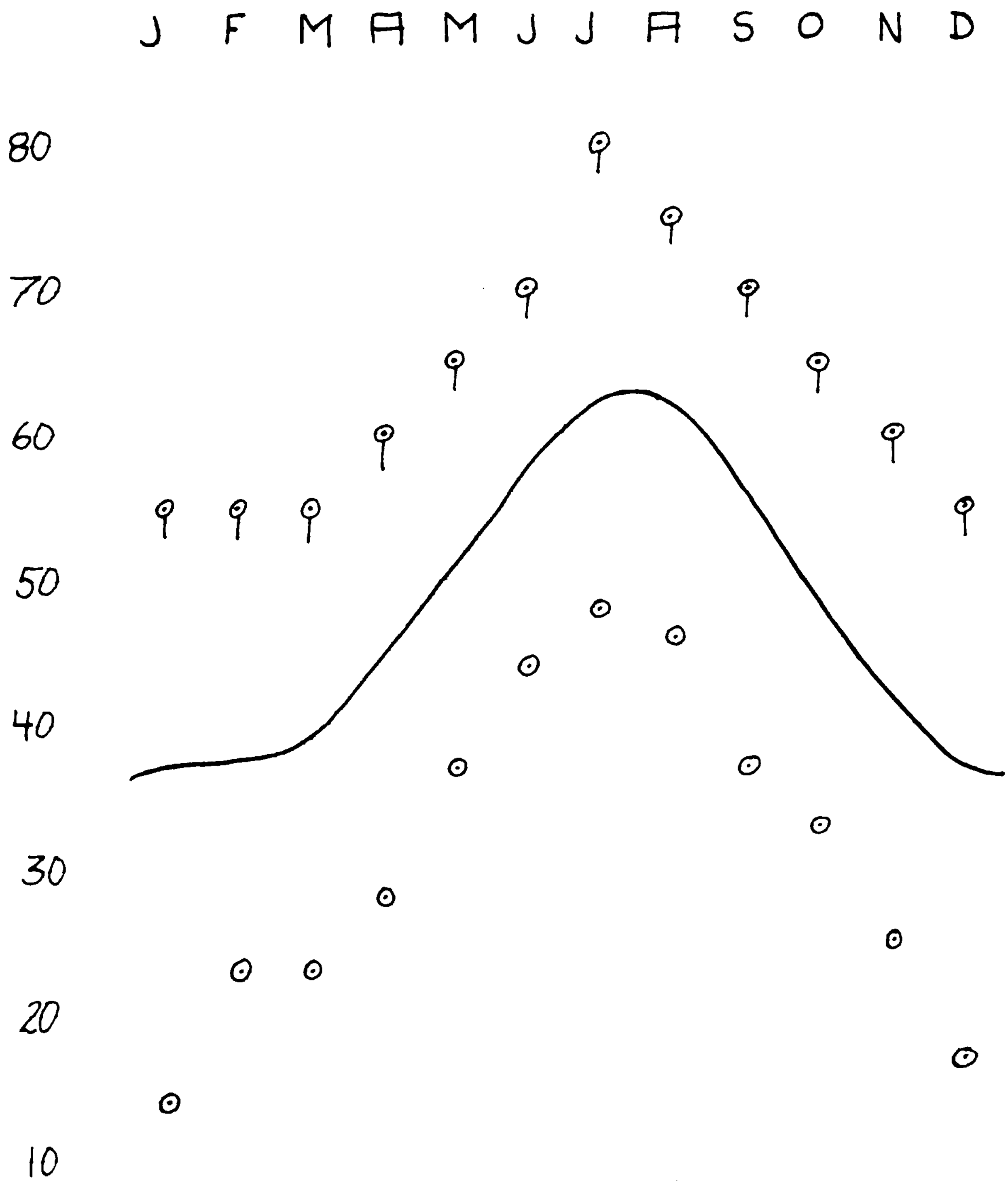
MAXIMUM TEMPERATURE DATA
BARDENAS REALES RANGE, SPAIN

1970 - 1975*



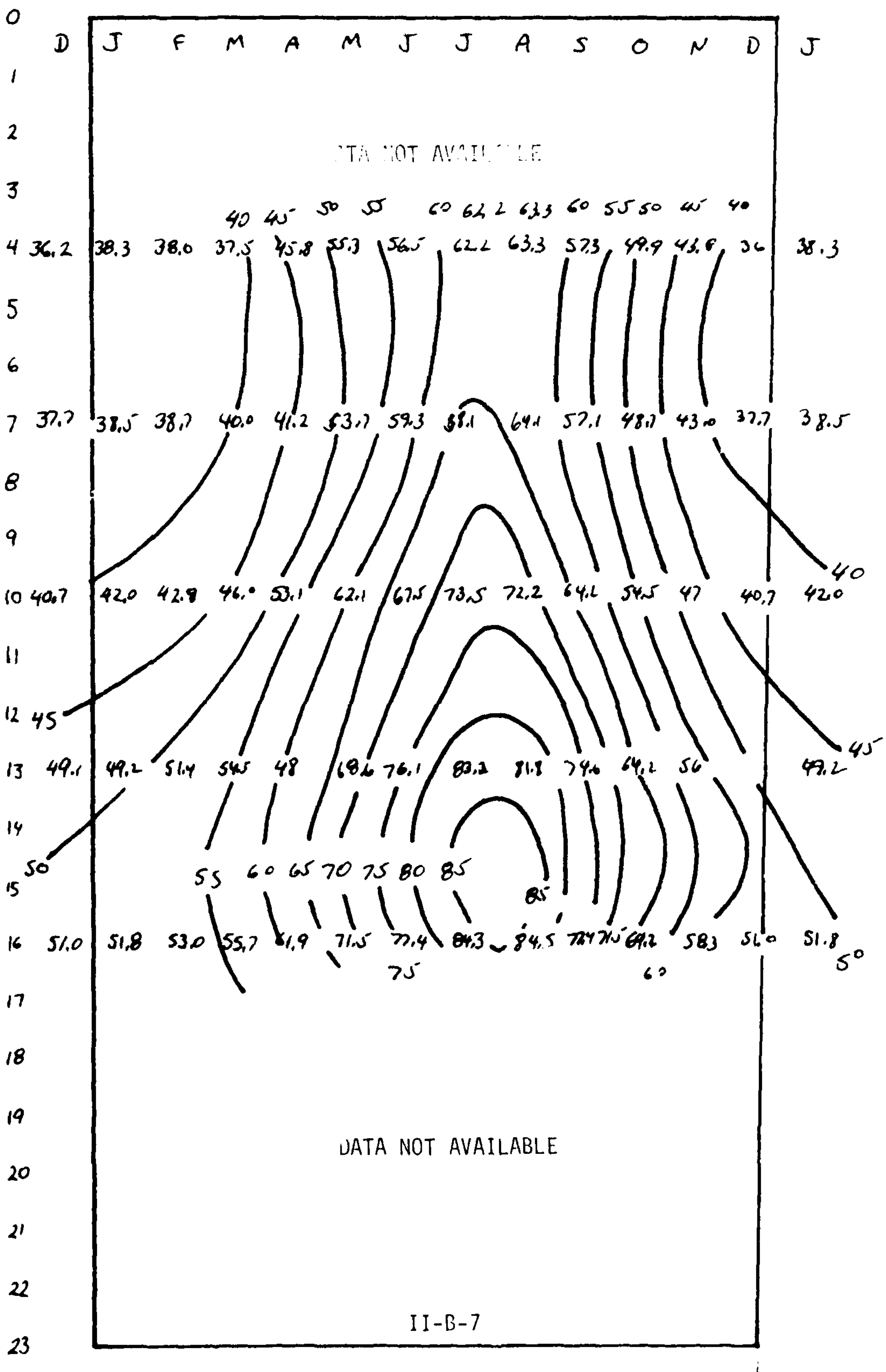
* [illegible] ABS[illegible] MAX[illegible] PERIOD OF RECORD 1970-1[illegible] LOWEST MAXIMUM ROUNDED DOWN [illegible] EAREST [illegible] DUE TO DATA LIMITATIONS

MINIMUM TEMPERATURE DATA
BARDENAS REALES RANGE, SPAIN
1970 - 1975*

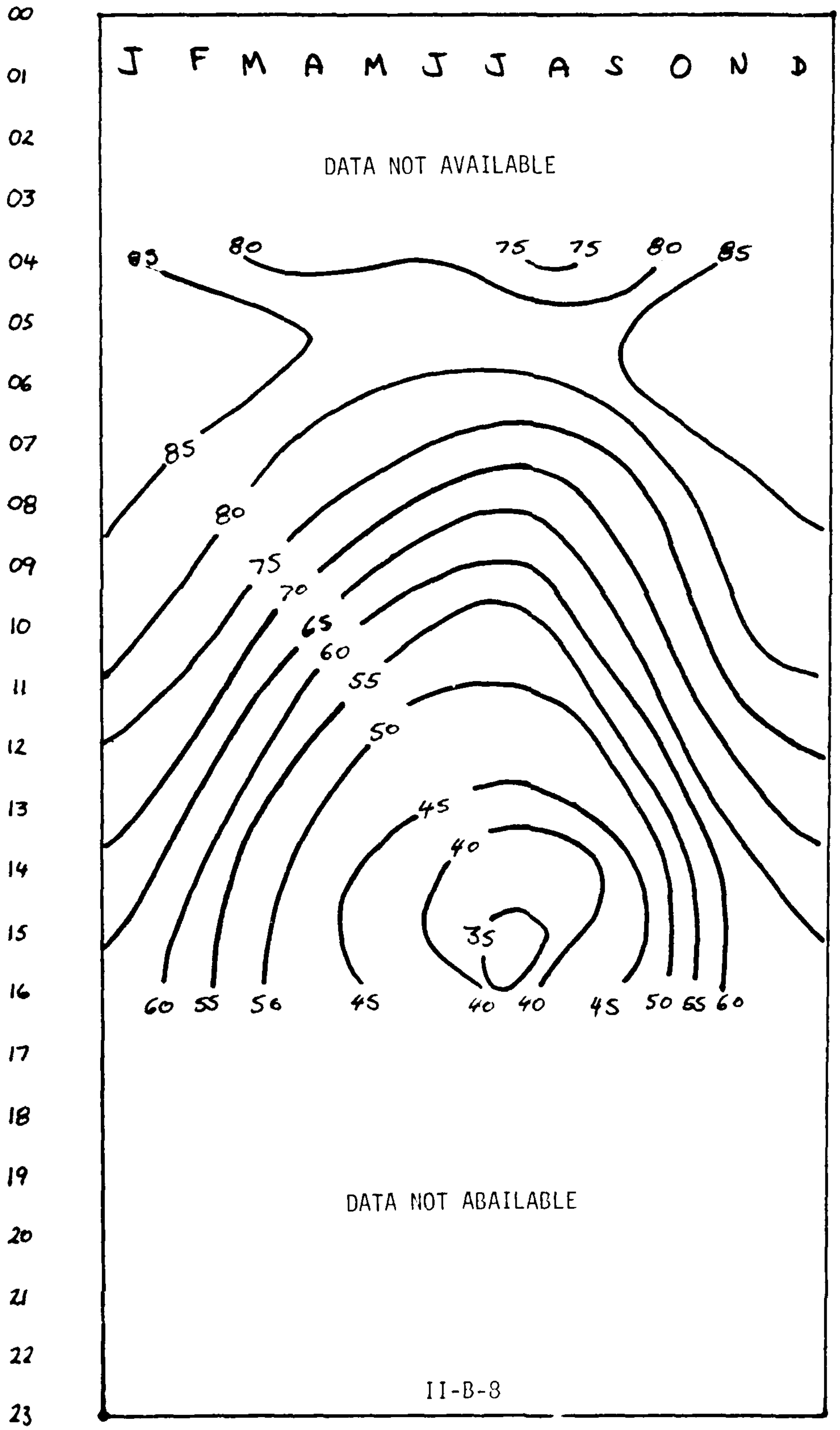


*NOTE: ABSOLUTE MINIMUM PERIOD OF RECORD 1970 - 1980 HIGHEST MINIMUM ROUNDED UP TO THE NEAREST 5° DUE TO DATA LIMITATIONS

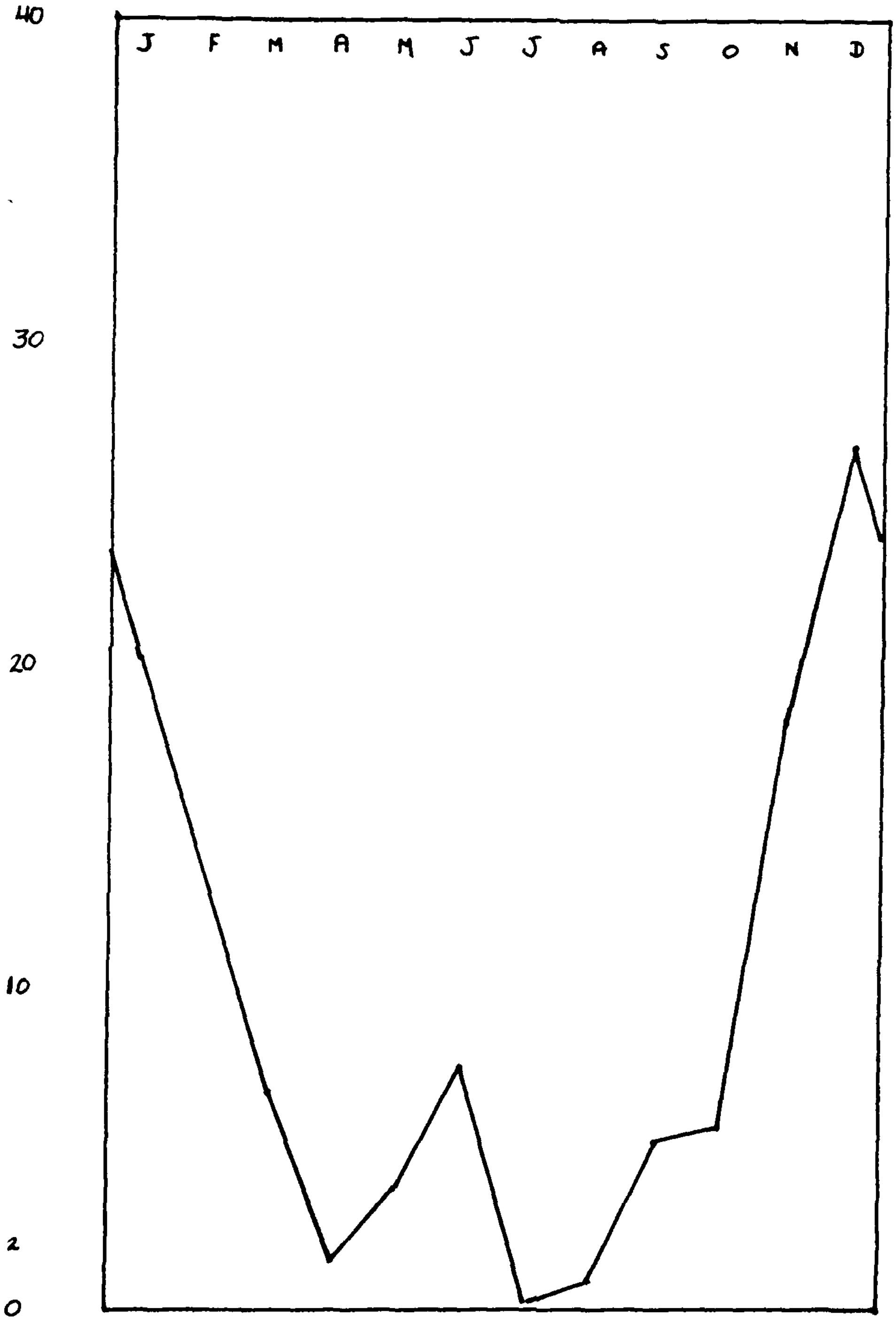
BARDENAS REALES RANGE, SPAIN
AVERAGE TEMPERATURES BY HOURS
BY MONTHS



BARDENAS REALES RANGE, SPAIN
AVERAGE HUMIDITY BY HOURS
BY MONTHS

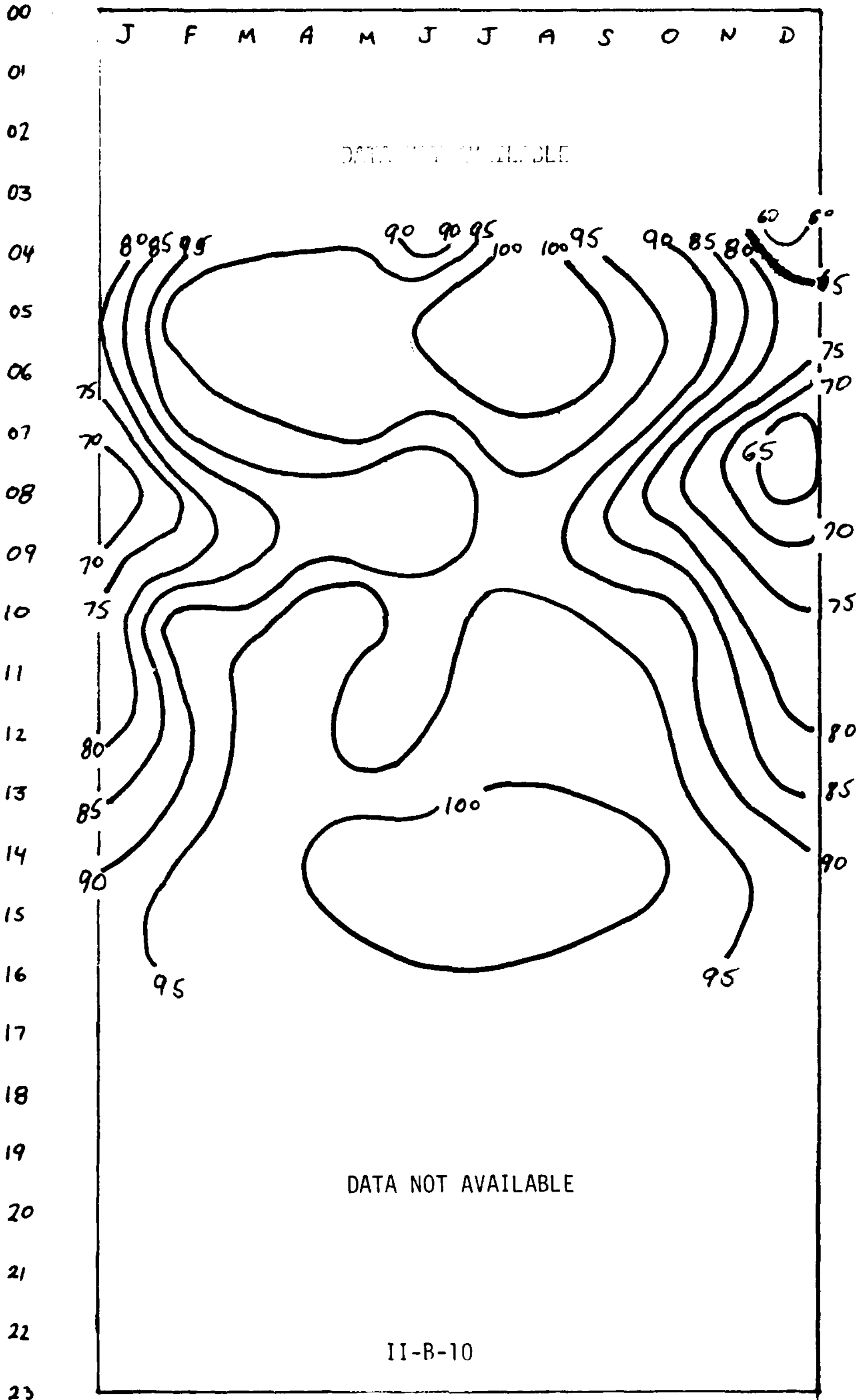


BARDENAS REALES RANGE, SPAIN
CEILING/VISIBILITY RANGE
MINIMUMS*

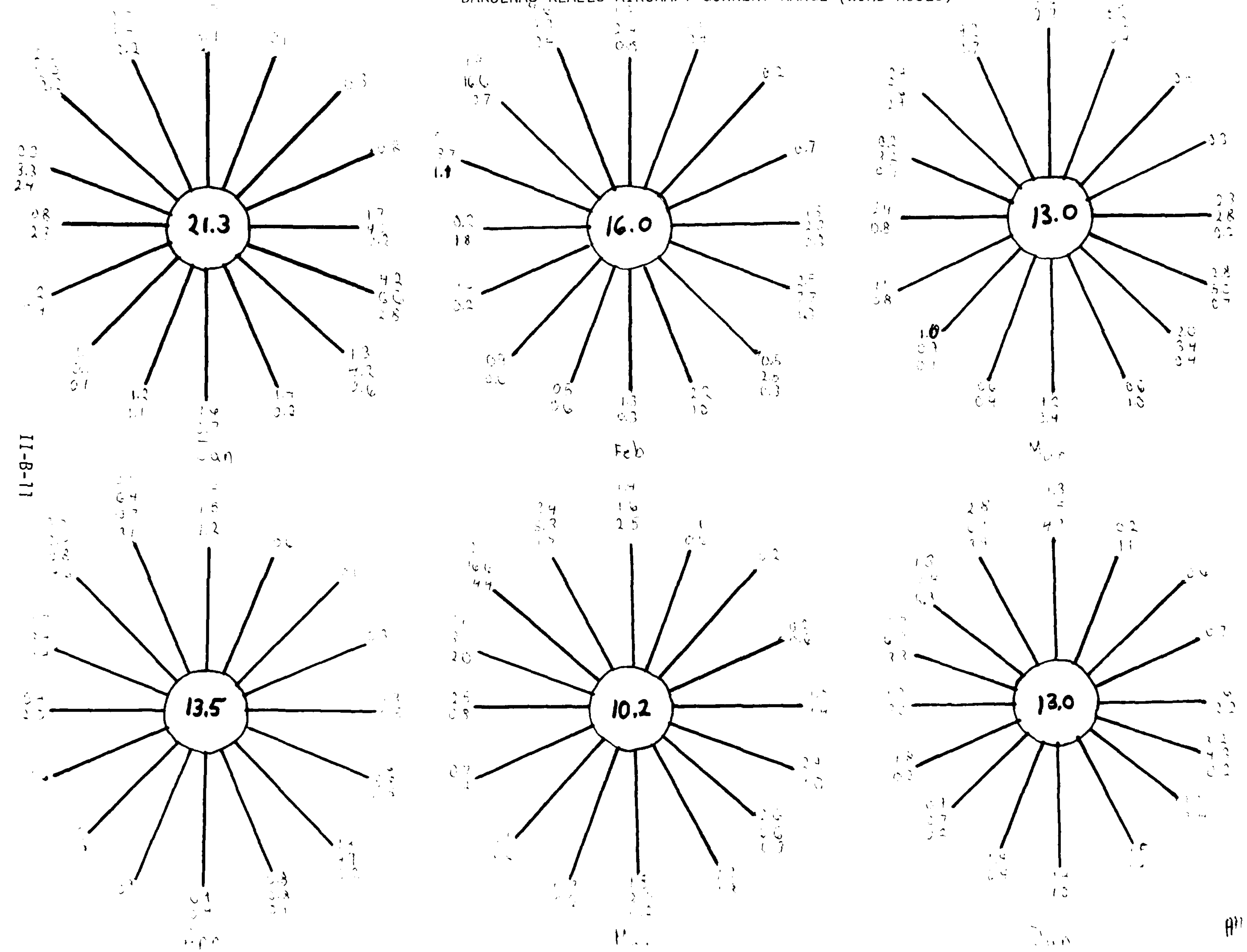


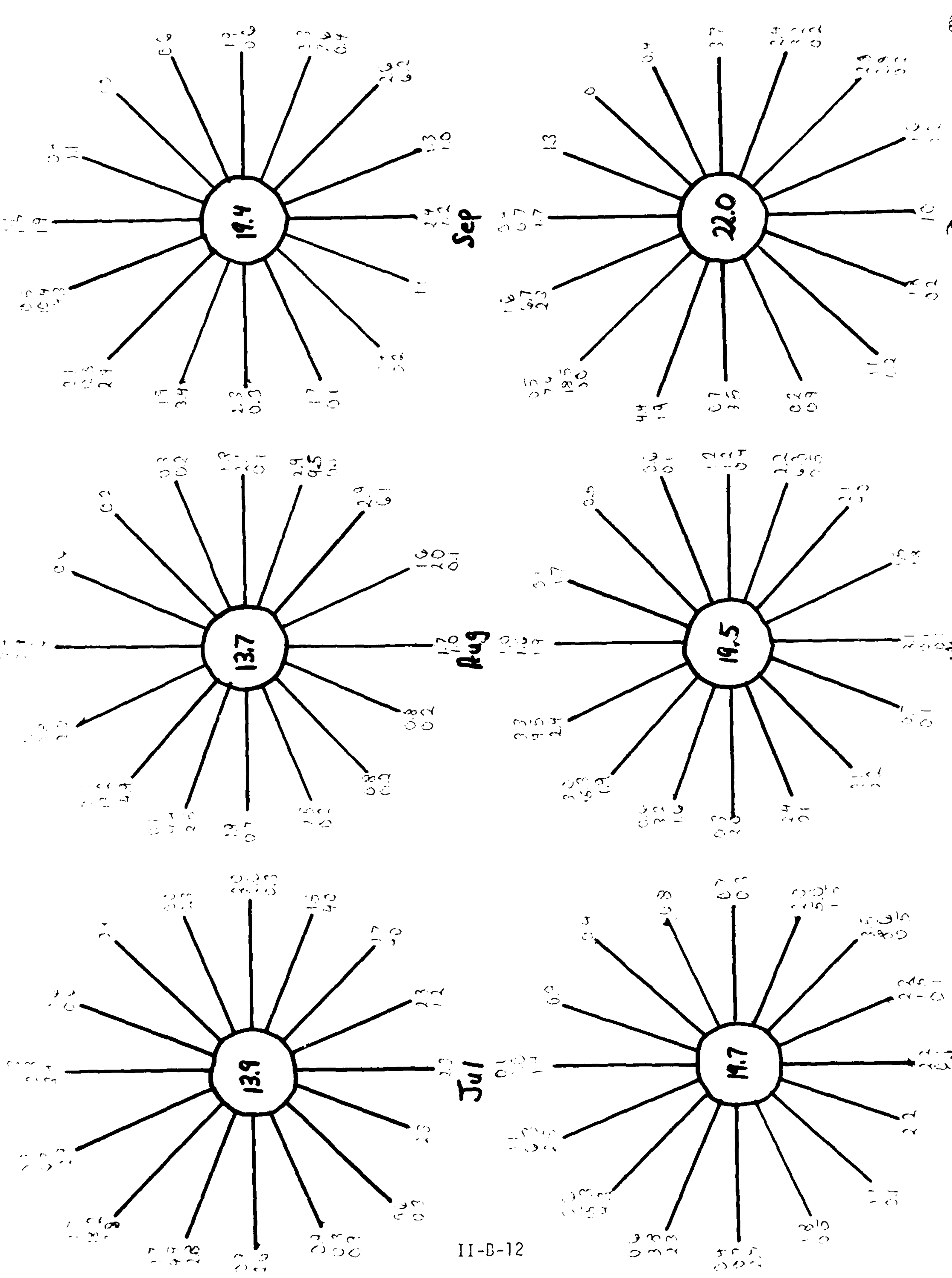
*3,000/4.0 Statue miles use due to data limitations

BARDENAS REALES RANGE, SPAIN
PERCENTAGE OF TIME RANGE OPEN
BY HOURS BY MONTHS



BARDENAS REALES AIRCRAFT GUNNERY RANGE (WIND ROSES)




Jul
13.9
Aug
13.7
Sep
19.4
Oct
19.7
Nov
19.5
Dec
22.0

WINDS ALOFT DATA FOR ZARAGOZA AIR BASE, SPAIN

The winds aloft data was taken from the Uniform Summary of Winds Aloft Observations prepared by the Climatic Center, USAF, date unknown. The period of record is January 1958 to September 1963, and includes two soundings per day. The seasons are: Winter- December to February, Spring- March to May, Summer- June to August, and Fall- September to November. The equivalent heights are:

1500 M = 4,921 ft
3000 M = 9,843 ft
6000 M = 19,685 ft
10,000 M = 32,808 ft

NOTE: A percentage frequency of 0.0 incicates that the event has occurred, but the frequency is less than 0.05 percent. An asterik denotes that the event has NOT occurred during the period of record.

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS
BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: [illegible] ZARAGOZA, SPAIN AB (STATION NAME) — WINTER (MO. OR SEASON) — RAWINS (TYPE OF OBSERVATION) — 1 [illegible] METERS (LEVEL)

YEARS: 5[illegible] 59 60 61 62 63

SPEED M S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
DIR / M P H	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS.	%	SUM	MEAN
N	.8	2.1	.2	.4	.6							35	4.1	750	19.7
NNE	.1	.1										2	.2	19	[illegible]
NE	.6	.2										8	.9	51	6.[illegible]
ENE	.4	.3	.2	.1								10	1.1	142	14.2
E	.4	1.0	.1									14	1.5	161	11.5
ESE	1.4	.4	.4									21	2.3	241	11.5
SE	1.2	1.5	.2	.1								28	[illegible]	34[illegible]	12.3
SSE	1.5	1.1	.5	.1								30	3.2	356	11.9
S	1.3	1.9	.2	.1								33	3.5	37[illegible]	11.3
SSW	1.[illegible]	1.3	.9	.1								[illegible]	3.1	45[illegible]	1[illegible].7
SW	1.0	2.0	2.3	.4								53	5.7	[illegible]95	16.9
WSW	.9	2.7	2.4	1.6	.1	.1						72	7.7	1627	[illegible]
W	2.0	3.8	3.1	1.9	1.7	.1						117	12.6	2731	23.[illegible]
WNW	2.5	6.8	5.9	1.3	.8							1[illegible]0	17.2	32[illegible]	[illegible]
NW	1.2	5.3	5.8	4.7	1.9	.6	.1					183	19.6	491[illegible]	[illegible]
NNW	1.5	3.2	2.4	3.8	2.3	.5		.1				129	13.8	[illegible]505	27.4
CALM												5	.5		
TOTALS	165	314	228	136	69	13	1	1				932	-	[illegible]9344	21.4
PERCENT	17.7	33.7	24.5	14.6	7.4	1.4	.1	.1				-	100.0		
MEAN SPEED (KNOTS)	[illegible].9	14.5	25.2	35.1	44.3	53.5	64.1	93.3							

θ	V_r	σ_v	ΣXY	ΣY^2	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]7	14.5771	2[illegible].158	136859.190	576370.739	1.156	1.39	16.543	11.5[illegible]8	12.672
N	**$\Sigma X/N$**	**σ_x**	**ΣX**	**ΣX^2**	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	**r**	* ψ	
[illegible]2	13.003	12.973	12118.356	314158.674	.907	1.59	[illegible]	1.436	
$\bar{V}$	**$\Sigma Y/N$**	**σ_y**	**ΣY**	**ΣY^2**	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{V}$	**ΣV**	**$\bar{V}$**	
12[illegible]	6.590	13.431	6141.755	262192.171	2.341	.68	19946	21.4	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V Scalar wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

14[illegible] ZARAGOZA, SPAIN AB — STATION / STATION NAME
WINTER — MO. OR SEASON
RAWINS — TYPE OF OBSERVATION
3000 METERS — LEVEL

5[illegible] 59 60 61 62 63
YEARS

SPEED M/S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
DIR / M.P.H.	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS.	%	SUM	MEAN
N	1.1	1.9	2.1	2.7	.8	.5	.1					89	9.2	2443	27.5
NNE	.4	2.1	.7	.6	.1	.1						39	4.0	78[illegible]	20.1
NE	.7	1.5	.4		.1							26	2.7	377	14.5
ENE	.8	1.0	.2	.1								21	2.2	276	13.1
E	1.0	1.0	.8	.1	.1							30	3.1	463	15.4
ESE	.6	1.6	.4		.1							26	2.7	377	14.5
SE	.7	.9	.3									19	2.0	249	13.1
SSE	1.0	.9	.1									20	2.1	227	11.4
S	1.2	1.1	.3									26	2.7	278	10.7
SSW	.5	.9	1.0	.6	.4							32	3.3	70[illegible]	22.1
SW	.4	1.5	1.3	.7	.4		.2					44	4.6	1096	24.9
WSW	.9	2.6	2.3	1.6	.7	.3	.1					82	8.5	2047	25.0
W	.9	3.5	4.5	3.5	1.9	.6	.5					149	15.5	4240	28.5
WNW	1.0	3.1	4.3	3.5	1.6	.8						138	14.3	389[illegible]	2[illegible].2
NW	1.0	3.6	1.9	3.8	1.6	1.2	.3					130	13.5	3803	29.3
NNW	.6	2.3	2.0	1.9	1.2	.8	.4					89	9.2	2706	30.4
CALM												3	.3		
TOTALS	128	285	218	185	85	43	16					963	-	23983	24.9
PERCENT	13.3	29.6	22.6	19.2	8.8	4.5	1.7					-	100.0		
MEAN SPEED (KNOTS) BY GROUP	5.3	14.9	25.1	34.8	43.9	54.0	63.9								

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
3[illegible]	15.1626	24.318	103464.565-	790910.982	1.310	1.60	17.425	16.963	14.185
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	r	* •	
963	13.157	17.144	12670.138	449671.692	1.303	1.71	.026-	1.027	
ψ	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{V}$	ΣV	$\bar{V}$	
12[illegible]	7.577-	17.246	7296.491-	341439.409	2.276-	.60	239[illegible]3	24.9	

- σ_x Standard deviation of east components
- σ_y Standard deviation of north components
- σ_v Standard vector deviation of wind velocity
- r Correlation coefficient of north and east components
- $\bar{V}$ Average wind speed
- V Scalar wind speed
- σ_a Standard deviation of wind components along the major axis of the distribution
- σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
- ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
- θ Resultant wind direction
- V_r Resultant wind speed
- σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: 14 1[illegible] — STATION NAME: ZARAGOZA, SPAIN AB — MO. OR SEASON: WINTER — TYPE OF OBSERVATION: RAWINS — LEVEL: 6000 METERS

YEARS: 5[illegible] 5[illegible] 60 61 62 63

SPEED M/S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
DIR / M.P.H.	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS.	%	SUM	MEAN
N	.2	1.7	1.2	1.7	1.2	.5	.8	.4	.1			79	8.1	[illegible]15	3[illegible].2
NNE	.1	1.0	.9	.6	.7	.6	.1	.2				42	4.3	1477	35.2
NE	.1	1.1	.5	.8	.3	.1	.1					32	3.3	841	26.6
ENE	.1	.4	.8	.1	.1	.2	.4					21	2.2	725	34.5
E	.3	1.1	.8	.6	.3							31	3.2	704	22.7
ESE	.3	.3		.1	.1			.1				14	1.4	313	22.4
SE	.4	.9	.4	.2								19	1.9	305	16.1
SSE	.4	.3	.4	.3								19	1.9	354	18.6
S	.3	.8	.3	.1	.1	.1						17	1.7	333	19.6
SSW	.1	.7	.2	.5	.2	.1	.3					21	2.2	666	31.7
SW	.3	1.3	1.1	1.7	.9	.6	.4	.1				64	6.6	2154	33.7
WSW	.5	2.2	2.5	1.7	2.3	1.0	1.5	.5	.1			121	12.4	4687	38.7
W	.3	2.0	2.5	2.8	4.0	1.7	2.0	.8				158	16.2	6593	41.5
WNW	.3	1.9	1.8	2.5	3.5	2.0	1.4	.6	.1			140	14.3	5[illegible]97	4[illegible].7
NW	.1	1.6	1.4	2.9	2.2	1.3	1.3	.6	.1			113	11.6	4690	41.5
NNW	.5	1.2	1.5	2.0	.8	.9	.8	.9				43	4.5	1668	39.4
CALM												2	.2		
TOTALS	45	194	161	191	153	92	91	43	4			976	-	35790	36.7
PERCENT	4.6	19.9	16.5	19.6	15.7	9.4	9.3	4.4	.4			-	100.0		
MEAN SPEED	6.3	15.3	25.3	34.9	44.5	53.9	65.1	85.0	107.4						

θ	V_r	σ_v	ΣXY	ΣV^2	$N\sigma_y/\Sigma X$	$^{**}\sigma_v/V_r$	σ_a	σ_b	σ_s
265	21.6835	35.777	102177.250-	1707117.437	1.242	1.64	27.011	23.417	20.12[illegible]
N	ΣX/N	σ_x	ΣX	ΣX^2	$N\sigma_x/\Sigma X$	$^{**}\sigma_v/\sigma_s$	r		
976	19.6[illegible]	28.212	19127.296	1044922.653	1.337	1.77	.121	1.153	
ψ	ΣY/N	σ_y	ΣY	ΣY^2	$N\sigma_y/\Sigma Y$	$^{**}V_r/\bar{V}$	ΣV	$\bar{V}$	
20	9.237-	24.359	9063.230-	662295.035	2.622-	.59	35790	36.7	

σ_x Standard deviation of east components
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σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V Scalar wind speed
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ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

WINDS ALOFT SUMMARY

(PERCENTAGE / FREQUENCY) OF DIRECTIONS BY SPEED GROUPS

STATION	STATION NAME	MO OR SEASON	TYPE OF OBSERVATION	LEVEL
14[illegible]	ZARAGOZA, SPAIN AB	WINTER	RAWINS	[illegible]

YEARS: 53 [illegible] 60 61 62 63

DIR \ SPEED M S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
M P H	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS	%	SUM	MEAN
N		.6	.7	.9	.8	1.0	1.4	1.1	.5			70	7.2	[illegible]	[illegible]
NNE	.2	.6	.3	.2	.5	.4	.4	.3	.2			37	3.8	1,72[illegible]	[illegible]
NE	.1	.4	.3	.2	.4	.2	.4	.5				25	[illegible]	1227	[illegible]
ENE	.1	.5	.2	.2	.4	.3	.1	.3	.1			22	2.3	[illegible]	[illegible]
E		.1	.6	.4	.2	.3	.2					[illegible]	[illegible]	[illegible]	[illegible]
ESE		.2	.2	.8	.2	.2						14	1.4	[illegible]	4.7
SE	.4	.1	.5		.2							12	[illegible]	[illegible]	[illegible]
SSE	.1	.5	.5	.1	.2	.1						15	1.3	[illegible]	[illegible]
S		.7	.5	.2	.1		.2					17	[illegible]	447	[illegible]
SSW	.1	.4	.3	.3	.1	.5	.3	.2				21	2.2	[illegible]	[illegible]
SW	.2	1.0	.8	.6	.7	1.2	1.0	.4	.3			42	4.4	[illegible]	[illegible]
WSW	.1	1.0	.8	1.4	1.7	1.0	2.1	2.8	1.0			113	11.7	[illegible]	[illegible]
W	.1	.6	1.7	2.2	2.7	2.2	4.5	2.8	1.5	.1		178	[illegible]	[illegible]	[illegible]
WNW	.2	.7	1.7	.8	2.4	1.5	2.6	3.1	.6			132	[illegible]	[illegible]	[illegible]
NW	.4	.7	.9	1.8	1.5	2.1	1.9	1.7	.5			113	11.7	[illegible]	[illegible]
NNW	.1	1.1	1.3	1.2	1.3	1.3	2.0	2.0	.8			116	12.2	[illegible]	[illegible]
CALM												1	.1		
TOTALS	21	92	108	108	131	121	166	164	55	1		[illegible]	-	2125	[illegible]
PERCENT	2.2	9.5	11.2	11.2	13.5	12.5	17.1	16.9	5.7	.1		-	100.0		
MEAN SPEED (KNOTS) BY GROUP	6.0	15.1	25.2	34.9	44.6	54.6	66.9	85.9	115.1	153.3					

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_v \Sigma X$	** σ_v / V_r	σ_a	σ_b	σ_s
[illegible]	33.577[illegible]	50.679	194624.914-	[illegible]273[illegible].634	1.1[illegible]	1.[illegible]	43.[illegible]	33.317	[illegible].187
N	**$\Sigma X/N$**	**σ_x**	**ΣX**	**ΣX^2**	* $N\sigma_x \Sigma X$	** σ_v / σ_s	**r**	*	
[illegible]	30.3[illegible]	34.443	2[illegible]47.411	217[illegible]5.752	1.[illegible]1	[illegible].79	.1[illegible]3	1.2[illegible]8	
ψ	**$\Sigma Y/N$**	**σ_y**	**ΣY**	**ΣY^2**	* $N\sigma_y \Sigma Y$	** $\bar{V}_r$	**ΣV**		
[illegible]	1[illegible].3[illegible]-	35.215	13[illegible]8.709-	13[illegible].321	2.447-	[illegible].2	52134	[illegible].8	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V Scalar wind speed
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DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

(PERCENTAGE) (FREQUENCY) OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: 14[illegible] STATION NAME: ZARAGOZA, SPAIN AB

MO. OR SEASON: SPRING

TYPE OF OBSERVATION: [illegible]

LEVEL: [illegible]

YEARS: 58 59 60 61 62 63

SPEED M/S / KNOTS / M.P.H. — DIR	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS: OBS	TOTAL ALL OBS: %	SPEED (KNOTS): SUM	SPEED (KNOTS): MEAN
N	1.2	1.3	.5	.2								[illegible]	[illegible]	[illegible]	[illegible]
NNE	1.0	.7										[illegible]	[illegible]	144	[illegible]
NE	1.3	.2										[illegible]	[illegible]	[illegible]	[illegible]
ENE	.4	.2										[illegible]	[illegible]	[illegible]	[illegible]
E	1.2	.8										[illegible]	[illegible]	173	[illegible]
ESE	1.2	1.9	.8									[illegible]	.9	[illegible]	[illegible]
SE	.4	2.2	.5	.1								[illegible]	[illegible]	[illegible]	[illegible]
SSE	1.3	2.1	.4									[illegible]	.8	[illegible]	[illegible]
S	[illegible]	2.2	.7									[illegible]	4.[illegible]	[illegible]	[illegible]
SSW	1.5	2.7	[illegible]	.2								[illegible]	[illegible]	[illegible]	[illegible]
SW	1.6	3.[illegible]	1.1	[illegible]								[illegible]	.8	[illegible]	[illegible]
WSW	1.6	3.3	1.5		.3							[illegible]	[illegible]	[illegible]	[illegible]
W	2.7	4.2	1.[illegible]	1.1	.5							[illegible]	[illegible]	[illegible]	[illegible]
WNW	1.6	7.7	[illegible]	.9	.1							[illegible]	[illegible]	[illegible]74	[illegible]
NW	1.0	5.4	6.9	4.7	1.2	.1						[illegible]	[illegible]	[illegible]	[illegible]
NNW	1.7	4.[illegible]	3.1	2.[illegible]	.9							[illegible]	[illegible]	[illegible]	[illegible]
CALM												[illegible]	[illegible]		
TOTALS	23[illegible]	44[illegible]	217	101	3[illegible]	1						1031	-	[illegible]	[illegible]
PERCENT	22.3	42.9	21.0	9.8	2.9	.1						-	[illegible]		
MEAN SPEED (KNOTS) BY GROUP	5.5	14.0	24.7	34.5	44.0	[illegible]									

θ	V_r	σ_v	ΣXY	ΣV^2	$N\sigma_y/\Sigma X$	σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	9.[illegible]	17.448	[illegible].747-	415[illegible]	1.467	1.75	14.[illegible]	9.[illegible]	[illegible].453

N	ΣX/N	σ_x	ΣX	ΣX^2	$N\sigma_x/\Sigma X$	σ_v/σ_s	r	ψ
1031	9.[illegible]7	11.[illegible]	[illegible].871	215[illegible]	1.244	1.[illegible]	.4[illegible]	[illegible]

V̄	ΣY/N	σ_y	ΣY	ΣY^2	$N\sigma_y/\Sigma Y$	$V_r/\bar{V}$	ΣV	V̄
[illegible]	4.[illegible]	[illegible]	[illegible].913-	1[illegible].1[illegible]	[illegible].[illegible]2-	.[illegible]7	[illegible]	1[illegible].1

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
V̄ Average wind speed
V Scalar wind speed
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DATA PROCESSING DIVISION
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AIR WEATHER SERVICE (MATS)

WINDS ALOFT SUMMARY

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

STATION: [illegible] | STATION NAME: [illegible] | MO. OR SEASON: [illegible] | ELEVATION: [illegible] | LEVEL: [illegible]

YEARS: [illegible] 59 60 61 62 63

SPEED (M.S. / KNOTS / MPH)	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	103+ / 200+ / 230+	TOTAL OBS	%	SPEED (KNOTS) SUM	MEAN
N	1.4	[illegible]	[illegible]	.7	.5	.2						77	7.4	[illegible]	[illegible]
NNE	1.4	1.7	.2	.4								[illegible]	[illegible]	[illegible]	[illegible]
NE	1.2	1.4	[illegible]	.1	.1							[illegible]	[illegible]	[illegible]	[illegible]
ENE	.8	1.4	.2									[illegible]	.4	[illegible]	[illegible]
E	1.2	1.2	.2	.1								[illegible]	.7	[illegible]	[illegible]
ESE	[illegible]	[illegible]	.3										1.5	[illegible]	[illegible]
SE	.6	[illegible]		.1	.1							[illegible]	[illegible]	[illegible]	[illegible]
SSE	.4	1.2	.4	.3								[illegible]	[illegible]	[illegible]	[illegible]
S	2.1	1.6	.6	.5								[illegible]	.7	[illegible]	[illegible]
SSW	.9	[illegible]	[illegible]	[illegible]	.1	.1						[illegible]	[illegible]	[illegible]	[illegible]
SW	.9	3.0	[illegible]	.9	[illegible]							[illegible]	[illegible]	[illegible]	.7
WSW	1.2	3.7	[illegible]	.9	.2	.1						[illegible]	[illegible]	[illegible]	.2
W	1.4	[illegible]	[illegible]	2.3	.3	.1	.1					[illegible]	[illegible]	[illegible]	.6
WNW	2.1	[illegible]	[illegible]	[illegible]	[illegible]	.2						154	[illegible]	[illegible]	1.8
NW	1.3	4.1	[illegible]	1.7	[illegible]	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]
NNW	1.1	[illegible]	[illegible]	1.2	.6	.1	.1					[illegible]	[illegible]	[illegible]	[illegible]
CALM												[illegible]	.3		
TOTALS	[illegible]	[illegible]	243	[illegible]	[illegible]	13	2					[illegible]	—	[illegible]	[illegible]
PERCENT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.2	.2					—	[illegible]		
[illegible]	.7	14.3	[illegible]	24.1	[illegible]	[illegible]	[illegible]								

WINDS ALOFT SUMMARY

PERCENTAGE FREQUENCY OF DIRECTIONS BY SPEED GROUPS

Direction	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Total All Obs: Obs	Total All Obs: %	Speed (Knots): Sum	Speed (Knots): Mean
N	[illegible]	2.[illegible]	[illegible]	1.[illegible]	.5	[illegible]	.4	.2				[illegible]	[illegible]	[illegible]	[illegible]
NNE	[illegible]	[illegible]	[illegible]	.7	[illegible]	.2	.1					[illegible]	[illegible]	[illegible]	[illegible]
NE	[illegible]	[illegible]	.5	.5	.2		.1					[illegible]	[illegible]	[illegible]	[illegible]
ENE	[illegible]	[illegible]	.7	.2		.2						[illegible]	.7	[illegible]	17.1
E	[illegible]	1.1	[illegible]	.3								[illegible]	[illegible]	435	17.4
ESE	[illegible]	[illegible]	.4									[illegible]	[illegible]	14	[illegible]
SE	[illegible]	[illegible]	[illegible]									1	1.4	[illegible]	[illegible]
SSE	[illegible]	[illegible]	[illegible]	.2	.2							4	2.3	[illegible]	[illegible]
S	.1	1.[illegible]	.7	[illegible]	.1	.5						[illegible]	[illegible]	11	[illegible]
SSW	[illegible]	1.[illegible]	1.[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]					[illegible]	[illegible]	[illegible]	[illegible]
SW	[illegible]	[illegible]	[illegible]	[illegible]	1.4	[illegible]	.4	.1				[illegible]	[illegible]	[illegible]	[illegible]
WSW	[illegible]	1.[illegible]	[illegible]	[illegible]	1.7	1.1	[illegible]	.2				112	[illegible]	37[illegible]	[illegible]
W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	[illegible]	[illegible]				124	[illegible]	[illegible]	[illegible]
WNW	1.[illegible]	1.[illegible]	[illegible]	2.7	[illegible]	1.2	1.[illegible]	.3				1[illegible]	[illegible]	47[illegible]	[illegible]
NW	.5	1.[illegible]	1.[illegible]	2.1	1.4	1.4	.4		.1			[illegible]	[illegible]	[illegible]	4.1
NNW	[illegible]	[illegible]	1.[illegible]	[illegible]	1.2	.6	.5	.3				1[illegible]	[illegible]	[illegible]	[illegible]
CALM												[illegible]	.5		
TOTAL	[illegible]3	[illegible]	[illegible]19	[illegible]	[illegible]	92	45	19	1			[illegible]	-	[illegible]	[illegible].9
PERCENT	[illegible]	24.4	[illegible]	19.[illegible]	[illegible].4	8.8	4.3	1.3	.1			-	[illegible]		
[illegible]	[illegible]	14.[illegible]	25.3	34.9	[illegible].6	[illegible]	[illegible].7	[illegible].2	100.0						

θ	V_r	σ_v	ΣXY	ΣY^2	$N\sigma_y/\Sigma X$	$**\sigma_v/V_r$	σ_a	σ_b	σ_s
[illegible]	17.[illegible]	[illegible].441	27[illegible].9704	1[illegible]971.[illegible]	1.295	1.75	[illegible]	[illegible]	[illegible].7.645
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	$N\sigma_x/\Sigma X$	$**\sigma_v/\sigma_s$	r		
[illegible]	17.[illegible]	[illegible].177	17[illegible].691	77[illegible]4.333	1.2[illegible]	1.73	[illegible]	1.1	
$\bar{V}$	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	$N\sigma_y/\Sigma Y$	$**V_r/\bar{V}$	ΣV	$\bar{V}$	
[illegible]	[illegible]	[illegible]	62[illegible].1434	526017.340	[illegible].4014	.57	3[illegible]	[illegible].5	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V [illegible] wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
γ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: [illegible] — STATION NAME: [illegible] — NO. OR SEASON: SPRING — TYPE OF OBSERVATION: [illegible] — LEVEL: [illegible]

YEARS: 5[illegible] 59 [illegible] 61 62 63

SPEED M.S. / KNOTS / M.P.H. — DIR	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	SPEED (KNOTS) SUM	SPEED (KNOTS) MEAN
N	.2	1.1	1.1	.7	1.[illegible]	.6	.3	.5	.3			76	[illegible].2	[illegible]	[illegible]
NNE	.2	.7	.4	.6	.5	.2	.3	.1				[illegible]	[illegible].3	[illegible]	[illegible]
NE	.2	.8	.4	.3		.2	.4					[illegible]3	2.2	71[illegible]	[illegible]
ENE	.2	.5	.7	.3	.6	.1	.2	.1				27	[illegible].6	91[illegible]	[illegible].7
E	.2	.2	.4	.1	.5		.1					1[illegible]	1.4	[illegible]86	[illegible].4
ESE	.4	.[illegible]	.1	.2								[illegible]	.7	16[illegible]	16.[illegible]
SE	.7	.4	.1									[illegible]2	1.1	12[illegible]	[illegible].2
SSE	.2	1.3	.3	.3		.1	.1					[illegible]4	[illegible].3	[illegible]	[illegible]
S	.2	.5	.[illegible]	.6	.6	.5	.1					[illegible]	[illegible].8	[illegible]	[illegible].6
SSW	.2	.7	.9	.7	.7	.7	1.1	.5				6	.3	[illegible]	[illegible].9
SW	.2	.4	1.5	.9	1.4	1.5	1.7	.7	.6			[illegible]	[illegible].8	4[illegible]	[illegible].9
WSW	.4	1.2	1.[illegible]	1.5	1.7	1.2	2.7	1.6				121	11.5	[illegible]	[illegible].4
W	.2	1.5	2.4	2.2	1.7	2.4	2.7	2.4	1.0			1[illegible]4	[illegible].4	[illegible]	[illegible].1
WNW	.2	1.4	1.2	1.7	2.0	1.[illegible]	2.5	2.2	1.1			1[illegible]4	14.6	[illegible]324	5[illegible].9
NW		.9	1.2	1.3	1.2	1.2	2.1	1.1	.5			[illegible]	[illegible].7	[illegible]13	[illegible].1
NNW	.3	.6	1.[illegible]	1.4	1.[illegible]	1.2	1.6	1.6	.1			[illegible]7	9.2	48[illegible]	[illegible].4
CALM												2	.2		
TOTALS	43	149	140	136	141	124	174	113	38			1[illegible]56	-	494[illegible]	46.8
PERCENT	[illegible].3	14.[illegible]	13.3	12.9	13.4	11.7	16.5	10.7	3.6			-	100.0		
MEAN SPEED (KNOTS) BY GROUP	5.5	14.1	25.2	35.5	45.2	54.4	[illegible]	84.6	114.2						

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_y/\Sigma X$	$**\sigma_v/V_r$	σ_a	σ_b	σ_s		
[illegible]	2[illegible].1[illegible]	45.149	[illegible]21.729-	304[illegible].604	1.1[illegible]	1.54	13.211	3[illegible]	[illegible].422		
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	* $N\sigma_x/\Sigma X$	$**\sigma_v/\sigma_s$	r	*			
[illegible]	[illegible]	3[illegible].1[illegible]2	2[illegible]79.151	1059276.716	1.1[illegible]1	1.73	.[illegible]	[illegible]			
r	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	* $N\sigma_y/\Sigma Y$	$**V_r/\bar{v}$	ΣV	$\bar{v}$			
.[illegible]3	[illegible]-	[illegible].679	7[illegible]-	1179120.[illegible]81	4.633-	.62	4[illegible]	46.8			

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{v}$ Average wind speed
V Scalar wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION	STATION NAME	MO. OR SEASON	TYPE OF OBSERVATION	LEVEL
[illegible]	[illegible], SPAIN [illegible]	[illegible]	[illegible]	[illegible]

YEARS: [illegible] 61 63

SPEED M S / KNOTS / M P H — DIR	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	%	SPEED (KNOTS) SUM	MEAN
N	1.4	.9	.2									27	.6	255	1.4
NNE	.8	.3										11	1.[illegible]	86	7.[illegible]
NE	.7	.2										9	.7	[illegible]	.[illegible]
ENE	.9	.3										[illegible]2	1.1	[illegible]	.3
E	1.2	1.3										27	[illegible].6	[illegible]	.[illegible]
ESE	1.[illegible]	3.0	.4									[illegible]2	[illegible]	[illegible]	11.2
SE	[illegible]	[illegible]	.3									74	7.0	78[illegible]	1[illegible]
SSE	[illegible].1	[illegible]										[illegible]4	[illegible].1	[illegible]	[illegible]
S	[illegible]	1.[illegible]	.4									63	[illegible].0	55[illegible]	[illegible]
SSW	.[illegible]	[illegible]	.[illegible]									[illegible]	.2	[illegible]	[illegible]
SW	[illegible].7	[illegible].1	.5	.2	.1							[illegible]	7.7	[illegible]	[illegible]
WSW	2.3	3.9	.9	.2								75	7.2	94[illegible]	1[illegible]
W	[illegible].5	4.[illegible]	.[illegible]									[illegible]	[illegible].7	[illegible]	[illegible]
WNW	2.[illegible]	7.7	[illegible].4	.1								17[illegible]	11.6	17[illegible]	[illegible]
NW	[illegible].7	[illegible]	7.1	1.3	.2							[illegible]	1[illegible].8	3[illegible]	1[illegible]
NNW	1.7	2.[illegible]	1.[illegible]	.[illegible]	.1							70	6.5	11[illegible]	1[illegible].6
CALM												11	1.0		
TOTALS	[illegible]	512	139	24	4							1[illegible]6	-	[illegible]34[illegible]5	12.7
PERCENT	[illegible].7	[illegible].5	11.2	2.3	.4							-	100.0		
MEAN SPEED (KNOTS) BY GROUP	.8	1[illegible]	2[illegible].3	33.[illegible]	[illegible].7										

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	[illegible].7112	13.625	57435.[illegible]	230[illegible]1.109	1.[illegible]14	2.[illegible]	11.356	6.713	7.[illegible]
N	**$\Sigma X/N$**	**σ_x**	**ΣX**	**ΣX^2**	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	**r**	*	
1[illegible]	[illegible]7	[illegible].165	[illegible]4.952	121[illegible].9[illegible]	1.[illegible]	1.[illegible]	.[illegible]7	1.76[illegible]	
$\bar{V}$	**$\Sigma Y/N$**	**σ_y**	**ΣY**	**ΣY^2**	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{V}$	**ΣV**	**$\bar{V}$**	
[illegible]	1.[illegible]	1[illegible].012	1424.271	[illegible]1.141	7.473	.45	13405	12.7	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V Scalar wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
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{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

[illegible] ZARAGOZA, SPAIN AB — STATION / STATION NAME

SUMMER — NO. OR SEASON

RAWINS — TYPE OF OBSERVATION

3000 [illegible] — LEVEL

[illegible] 52-63 — YEARS

SPEED M/S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
DIR / M.P.H.	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS.	%	SUM	MEAN
N	.3	1.8	.2	.1								31	[illegible]	[illegible]	[illegible]
NNE	.6	.7										13	1.2	[illegible]	[illegible]
NE	.4	.3										13	1.2	[illegible]	[illegible]
ENE	.5	.6										11	1.0	113	[illegible]
E	.3	.5	.1									15	1.4	134	[illegible]
ESE	.6	.7	.2									16	1.5	179	11.2
SE	1.1	.7	.3	.1								23	2.1	243	[illegible]
SSE	.7	.8	.1	.1								19	1.8	212	11.2
S	1.6	1.1	.5	.4								38	3.5	[illegible]	13.7
SSW	1.3	4.1	1.2	.2								73	6.8	[illegible]	[illegible]
SW	1.3	7.3	3.3	.5	.1							[illegible]	[illegible]	[illegible]	[illegible]
WSW	1.0	9.6	5.4	[illegible]	.3							[illegible]	19.1	[illegible]	[illegible]
W	2.2	11.0	5.1	.9								[illegible]	19.3	[illegible]	17.3
WNW	1.7	5.3	2.8	.6	.1							112	[illegible]	[illegible]	17.0
NW	2.2	5.6	2.0	.4	.1							110	[illegible]	1713	15.6
NNW	1.2	2.5	.5	.1								47	4.4	[illegible]	[illegible]
CALM												2	.2		
TOTALS	209	565	237	[illegible]	6							1075	-	17421	16.2
PERCENT	19.4	52.6	22.0	5.2	.6							-	100.0		-
MEAN SPEED (KNOTS)	5.8	14.6	24.5	33.7	45.7										

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	11.2[illegible]	[illegible].224	[illegible]	354118.548	.[illegible]	1.[illegible]	10.283	9.[illegible]	8.1[illegible]
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	r	*	
[illegible]	11.[illegible]	1[illegible]	[illegible]	[illegible]	.[illegible]	1.73	.044	1.046	
ψ	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{v}$	ΣV	$\bar{v}$	
[illegible]	2.0[illegible]	[illegible]	[illegible]52.145	[illegible]81.063	4.012	.69	17419	16.2	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{v}$ Average wind speed
[illegible] wind speed
[illegible]

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds
** [illegible]

DATA PROCESSING DIVISION
[illegible], USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION	STATION NAME	MO. OR SEASON	TYPE OF OBSERVATION	LEVEL
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

YEARS [illegible] 61 62 63

DIR \ SPEED M/S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS. OBS.	%	SPEED (KNOTS) SUM	MEAN
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
M P H	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230				
N	[illegible]	1.3	[illegible]	.7								[illegible]	[illegible]	[illegible]	[illegible]
NNE	.3	.7	[illegible]	.1								[illegible]	1.5	[illegible]	[illegible]
NE	.4	.2	[illegible]									[illegible]	[illegible]	[illegible]	[illegible]
ENE	.5	.3	.1	.1								[illegible]	1.3	[illegible]	[illegible]
E	.2	.4										[illegible]	.6	[illegible]	[illegible]
ESE	.4	.3										7	.5	[illegible]	[illegible]
SE	.4	.4	[illegible]									[illegible]	.9	[illegible]	[illegible]
SSE	[illegible]	[illegible]	.5									[illegible]	1.6	[illegible]	[illegible]
S	.9	[illegible]	.4	.4	.3							31	[illegible]	[illegible]	[illegible]
SSW	.5	1.7	1.1	[illegible]	.6	.1						[illegible]	4.7	[illegible]	[illegible]
SW	.8	[illegible]	[illegible]	[illegible]	1.[illegible]	1.1	.4					[illegible]	12.1	[illegible]	[illegible]
WSW	.6	[illegible]	[illegible]	[illegible]	[illegible]	.6	.5	.3				[illegible]	[illegible]	[illegible]	[illegible]
W	.5	[illegible]	[illegible]	[illegible]	[illegible]	1.3	.4	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]
WNW	.6	4.2	[illegible]	[illegible]	1.2	.4	.1	.1				137	[illegible]	[illegible]	5.6
NW	[illegible]	3.[illegible]	1.[illegible]	.6	.1	.4		.1				[illegible]	[illegible]	[illegible]	[illegible]
NNW	.3	[illegible]	1.3	.7	.3	.2	.1					[illegible]	[illegible]	[illegible]	[illegible]
CALM												2	.2		
TOTALS	[illegible]	[illegible]	[illegible]	232	125	43	15	7				[illegible]	-	[illegible]	[illegible]
PERCENT	[illegible]	[illegible]	[illegible]	21.3	11.5	4.[illegible]	1.4	.6				-	[illegible]		
MEAN SPEED (KNOTS)	[illegible]	[illegible]	[illegible]	[illegible]	44.4	53.6	64.1	[illegible]							

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_v/\Sigma X$	$**\sigma_v/V_r$	σ_a	σ_b	σ_s
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.760	[illegible]	17.351	[illegible]	14.326
N	**$\Sigma X/N$**	**σ_x**	**ΣX**	**ΣX^2**	* $N\sigma_x/\Sigma X$	$**\sigma_v/\sigma_s$	**r**	**ψ**	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.217	
$\bar{V}$	**$\Sigma Y/N$**	**σ_y**	**ΣY**	**ΣY^2**	* $N\sigma_y/\Sigma Y$	$**V_r/\bar{V}$	**ΣV**	**$\bar{V}$**	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.76	[illegible]	[illegible]	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
V Scalar wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: [illegible] STATION NAME: [illegible] MO. OR SEASON: [illegible] TYPE OF OBSERVATION: [illegible] LEVEL: [illegible]

YEARS: [illegible] 60 61 62 63

SPEED M/S	1-4	5-10	11-15	16-20	21-25	26-30	31-38	39-51	52-77	78-102	≥103	TOTAL ALL OBS.		SPEED (KNOTS)	
KNOTS	1-9	10-19	20-29	30-39	40-49	50-59	60-74	75-99	100-149	150-199	≥200				
DIR / M.P.H.	1-10	11-22	23-33	34-45	46-56	57-68	69-85	86-114	115-172	173-229	≥230	OBS.	%	SUM	MEAN
N	[illegible]	1.2	[illegible]	.5	.4	[illegible]	.4					[illegible]	[illegible]	[illegible]	[illegible]
NNE		[illegible]	[illegible]	[illegible]	.2	.1	.2					[illegible]	[illegible]	[illegible]	[illegible]
NE	.2	.4	[illegible]	[illegible]	.1							[illegible]	.4	46	[illegible]
ENE	[illegible]	[illegible]	[illegible]	.3								11	[illegible]	[illegible]	[illegible]
E	.1	[illegible]	.4									[illegible]	[illegible]	[illegible]	[illegible]
ESE	.2	[illegible]	[illegible]	.1								[illegible]	[illegible]	[illegible]	[illegible]
SE	.1	[illegible]	[illegible]									[illegible]	[illegible]	[illegible]	[illegible]
SSE	.1	[illegible]	[illegible]	[illegible]	.1	.2						[illegible]	1.2	[illegible]	[illegible]
S	.3	[illegible]	[illegible]	[illegible]	[illegible]	.2		.1				[illegible]	[illegible]	[illegible]	[illegible]
SSW	.2	1.1	[illegible]	.7	[illegible]	[illegible]	[illegible]	.2				7	[illegible]	[illegible]	[illegible]
SW	.4	[illegible]	[illegible]	[illegible]	[illegible]	1.4	[illegible]	[illegible]	.1			[illegible]	[illegible]	[illegible]	[illegible]
WSW	[illegible]	1.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.1	.5			[illegible]	.1	[illegible]	[illegible]
W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.6	[illegible]	.5			[illegible]	[illegible]	[illegible]	[illegible]
WNW	[illegible]	1.6	[illegible]	[illegible]	[illegible]	1.3	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]
NW	[illegible]	[illegible]	1.7	[illegible]	[illegible]	.7	.9	.7				[illegible]	[illegible]	[illegible]	[illegible]
NNW	.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.3	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]
CALM															
TOTALS	[illegible]	[illegible]	131	[illegible]	[illegible]	112	133	72	13			[illegible]	-	[illegible]	[illegible]
PERCENT	[illegible]	14.4	[illegible]	[illegible]	[illegible]	[illegible]	12.2	6.6	1.2			-	[illegible]		
MEAN SPEED (KNOTS) BY SPEED	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_v/\Sigma X$	$**\sigma_v/V_r$	σ_a	σ_b	σ_s
[illegible]	[illegible]	[illegible]	[illegible]	[illegible].573	[illegible]	1.16	[illegible]	[illegible]	[illegible]
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	* $N\sigma_x/\Sigma X$	$**\sigma_v/\sigma_s$	r	*	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
ψ	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	* $N\sigma_y/\Sigma Y$	$**V_r/\bar{v}$	ΣV	$\bar{v}$	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.73	[illegible]	[illegible]	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{v}$ Average wind speed
V Scalar wind speed
• Ratio of standard deviations $=\sigma$ / σ_s

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds
** Wherever ratio [illegible] 999.9999

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

STATION: [illegible] STATION NAME: [illegible] MO. OR SEASON: [illegible] TYPE OF OBSERVATION: [illegible] LEVEL: [illegible]

YEARS: [illegible] 62 63

SPEED / DIR (M.S / KNOTS / M.P.H.)	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	SPEED (KNOTS) SUM	SPEED (KNOTS) MEAN
N	.7	.7	.6	.3								17	2.1	[illegible]	[illegible]
NNE	.9	.4	.1									13	1.4	[illegible]	[illegible]
NE	.7	.1	.1									8	.9	76	[illegible]
ENE	1.1	.9										18	2.0	14[illegible]	7.[illegible]
E	1.1	1.2	.3									24	2.6	[illegible]	10.7
ESE	1.2	2.2	.2									33	3.6	[illegible]	1[illegible].7
SE	1.9	3.2	[illegible]	.3	.1							52	5.7	711	13.7
SSE	2.7	2.4	[illegible]	.1								45	5.0	[illegible]	1[illegible].4
S	3.2	2.3	[illegible]	.1								59	6.5	56[illegible]	1[illegible]
SSW	2.2	3.4	.9	.1								60	6.6	[illegible]	12.6
SW	3.4	4.2	.4									55	6.1	[illegible]	1[illegible].7
WSW	1.7	3.6	1.7	.4								67	7.4	[illegible]	[illegible]
W	2.3	5.3	2.1	.7	.1							97	10.7	[illegible]	[illegible]
WNW	[illegible].5	5.3	3.1	.8								111	12.2	1775	1[illegible].0
NW	1.1	6.8	6.2	2.4	.8	.1						131	14.4	[illegible]	22.2
NNW	1.4	3.7	3.9	2.8	.9							106	11.7	2408	2[illegible].7
CALM												10	1.1		
TOTALS	[illegible]	417	156	73	17	1						908	-	[illegible]4183	15.6
PERCENT	25.3	45.9	17.2	8.0	1.9	.1						-	100.0		
MEAN SPEED (KNOTS) BY GROUP	5.6	12.7	24.6	34.3	42.2	23.5									

θ	V_r	σ_v	ΣXY	ΣY^2	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	7.4293	[illegible]	70[illegible].716	[illegible].369	1.334	2.27	14.423	8.777	[illegible].744
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	r	* ψ	
[illegible]	7.[illegible]	[illegible]	[illegible]	1[illegible].425	1.640	1.72	.4324	1.[illegible]	
ψ	$\Sigma Y/N$	σ_y	ΣY	[illegible]	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{v}$	ΣV	$\bar{v}$	
1[illegible]4	2.34[illegible]	1[illegible]	2132.165	1[illegible].419	5.577	.47	14183	15.6	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{v}$ Average wind speed
V Scalar wind speed

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS
BY SPEED GROUPS

WINDS ALOFT SUMMARY

[illegible] [illegible] — STATION / STATION NAME; AUTUMN — MO. OR SEASON; RAWINS — TYPE OF OBSERVATION; [illegible] 5 — LEVEL

[illegible] 60 61 62 63 — YEARS

SPEED M.S / KNOTS / M.P.H. — DIR	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	SPEED (KNOTS) SUM	SPEED (KNOTS) MEAN
N	[illegible]	2.4	.4	1.5	.1	.1						71	7.[illegible]	[illegible]	[illegible]
NNE	.6	.3	.2									16	1.7	215	[illegible]
NE	.5	1.1	.2	.1								19	[illegible]	[illegible]	[illegible]
ENE	.4	1.5	1.1	.1								[illegible]	[illegible].1	[illegible]	[illegible]
E	.5	1.4	.7	.1								[illegible]3	[illegible]	[illegible]	[illegible]
ESE	.5	1.1	.4									[illegible]9	[illegible]	[illegible]	[illegible].3
SE	.7	.6		.1								14	1.[illegible]	[illegible]4	[illegible].1
SSE	.4	1.6	.1									[illegible]	[illegible].1	[illegible]	[illegible]
S	1.4	[illegible]	1.1	.[illegible]	.1							[illegible]	[illegible]	1[illegible]	[illegible].4
SSW	1.1	[illegible].5	1.9	.5	.2							68	7.2	[illegible]	[illegible].9
SW	.3	4.6	2.[illegible]	.[illegible]	.4		.1					1[illegible]	11.3	[illegible]	[illegible].6
WSW	[illegible]	[illegible].2	[illegible]	1.4	.3	.1						1[illegible]1	1[illegible].7	[illegible]	[illegible].7
W	.[illegible]	6.4	[illegible]	[illegible].7	.3	.1						1[illegible]	1[illegible].5	[illegible]4	[illegible].2
WNW	2.[illegible]	3.3	3.5	[illegible].4	.3	.2						1[illegible]	11.3	2[illegible]	[illegible].2
NW	1.1	3.8	2.[illegible]	1.5	.6	.1						[illegible]9	.[illegible]	[illegible]	[illegible]
NNW	1.3	2.1	1.[illegible]	.5	.3	.1						[illegible]9	.[illegible]	[illegible]9	[illegible]
CALM												2	.2		
TOTALS	[illegible]7	412	[illegible]	1[illegible]	33	7	1					942	-	[illegible]779[illegible]	[illegible]
PERCENT	[illegible].7	43.7	24.3	10.7	3.5	.7	.1					-	1[illegible].[illegible]		
MEAN SPEED	[illegible]	14.4	25.6	[illegible].4	44.1	52.8	60.3								

θ	V_r	σ_v	ΣXY	ΣV^2	$N\sigma_y/\Sigma X$	$^{**}\sigma_v/V_r$	σ_a	σ_b	σ_s
[illegible]76	9.[illegible]10	1[illegible].7[illegible]	[illegible].[illegible]	443[illegible].13[illegible]	[illegible].[illegible]10	[illegible].16	14.637	1[illegible].1[illegible]	[illegible].65[illegible]
N	$\Sigma X/N$	σ_x	ΣX	ΣX^2	$^{*}N\sigma_x/\Sigma X$	$^{**}\sigma_v/\sigma_s$	r	$\bar{v}$	
[illegible]	[illegible].[illegible]	13.[illegible]	[illegible]21.249	240[illegible].[illegible]13	1.433	1.[illegible]4	.[illegible]	1.11[illegible]	
	$\Sigma Y/N$	σ_y	ΣY	ΣY^2	$^{*}N\sigma_y/\Sigma Y$	$^{**}V_r/\bar{v}$	Σv	$\bar{v}$	
[illegible]	.[illegible]	14.[illegible]	451.976	[illegible]359.[illegible]91	16.134	.48	17733	[illegible].[illegible]	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{v}$ Average wind speed
$\tilde{v}$ [illegible] wind speed
[illegible]

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds
** [illegible]

DATA PROCESSING DIVISION
CLIMATIC CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

[illegible] STATION — [illegible] STATION NAME — AUTUMN NO. OR SEASON — [illegible] TYPE OF OBSERVATION — [illegible] LEVEL

[illegible] 61 [illegible] YEARS

SPEED / DIR	M/S 1-4 / KNOTS 1-9 / M.P.H. 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	SPEED (KNOTS) SUM	SPEED (KNOTS) MEAN
N	[illegible]	[illegible]	1.3	1.2	.7	.6	.2	.1				63	6.6	[illegible]	[illegible]
NNE	.1	.2	[illegible]	[illegible]	.1	.1						[illegible]	[illegible]	[illegible]	[illegible]
NE	.4	.1	.4	[illegible]	.2	[illegible]	.1					[illegible]	[illegible]	47	[illegible]
ENE	.2	.9	1.[illegible]	.4	.1							[illegible]	.7	[illegible]	[illegible]
E	.2	1.3	.4	.2	.1							31	[illegible]	[illegible]	[illegible]
ESE	.4	.7	.1									14	1.[illegible]	[illegible]	[illegible]
SE	.3	[illegible]	.1	.1								[illegible]	[illegible]	[illegible]	[illegible]
SSE	[illegible]	.4	[illegible]	[illegible]	.2	.1						[illegible]	[illegible]	[illegible]	[illegible]
S	.1	1.6	.6	[illegible]	.4	.1	.1					[illegible]	[illegible]	[illegible]	[illegible]
SSW	.1	2.4	1.4	1.4	.4	.3	.2					[illegible]	[illegible]	[illegible]	.9
SW	.3	[illegible]	[illegible]	[illegible]	1.7	[illegible]	.1	.1				113	11.9	[illegible]	[illegible]
WSW	.4	[illegible]	[illegible]	[illegible]	1.3	[illegible]	.1	.1				122	[illegible]	[illegible]	[illegible]
W	.3	[illegible]	[illegible]	[illegible]	[illegible]	1.2	.3	.1				[illegible]	[illegible]	4111	[illegible]
WNW	.5	[illegible]	2.1	[illegible]	1.[illegible]	[illegible]	.7	.2				[illegible]	11.4	[illegible]	[illegible]
NW	.5	[illegible]	[illegible]	1.4	1.2	[illegible]	.6					[illegible]	[illegible]	[illegible]	[illegible]
NNW	.1	1.[illegible]	1.[illegible]	[illegible]	1.0	.3	.1	.1				[illegible]	6.7	[illegible]	[illegible]
CALM												4	.4		
TOTALS	[illegible]	265	[illegible]	168	112	56	34	7				[illegible]	-	[illegible]	[illegible]
PERCENT	.6	27.[illegible]	23.6	17.6	11.8	5.9	3.6	.7				-	[illegible]		
MEAN SPEED	[illegible]	15.[illegible]	[illegible]	34.6	[illegible]	53.6	[illegible]	[illegible]							

θ	V_r	σ_v	ΣXY	ΣV^2	* $N\sigma_v/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	[illegible]	[illegible]	[illegible]	[illegible].711	1.331	1.21	21.23	[illegible].667	[illegible]
N	**$\Sigma X/N$**	**σ_x**	**ΣX**	**ΣX^2**	*** $N\sigma_x/\Sigma X$**	**** σ_v/σ_s**	**r**		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.118	
ψ	**$\Sigma Y/N$**	**σ_y**	**ΣY**	**ΣY^2**	*** $N\sigma_y/\Sigma Y$**	**** $V_r/\bar{V}$**	**ΣV**	**$\bar{V}$**	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

σ_x Standard deviation of east components
σ_y Standard deviation of north components
σ_v Standard vector deviation of wind velocity
r Correlation coefficient of north and east components
$\bar{V}$ Average wind speed
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σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds

DATA PROCESSING DIVISION
[illegible] CENTER, USAF
AIR WEATHER SERVICE (MATS)

{PERCENTAGE / FREQUENCY} OF DIRECTIONS BY SPEED GROUPS

WINDS ALOFT SUMMARY

[illegible] STATION | [illegible] STATION NAME | [illegible] NO. OR SEASON | [illegible] TYPE OF OBSERVATION | [illegible] LEVEL

[illegible] 41 42 61 YEARS

DIR \ SPEED (M/S / KNOTS / MPH)	1-4 / 1-9 / 1-10	5-10 / 10-19 / 11-22	11-15 / 20-29 / 23-33	16-20 / 30-39 / 34-45	21-25 / 40-49 / 46-56	26-30 / 50-59 / 57-68	31-38 / 60-74 / 69-85	39-51 / 75-99 / 86-114	52-77 / 100-149 / 115-172	78-102 / 150-199 / 173-229	≥103 / ≥200 / ≥230	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	SPEED (KNOTS) SUM	SPEED (KNOTS) MEAN
N	[illegible]	[illegible]	[illegible]	[illegible]	.8	[illegible]	.8	.6	.2			[illegible]	.4	[illegible]	[illegible]
NNE	[illegible]	.3	.1	[illegible]	.6	.1	.4	.1				7	.3	[illegible]	[illegible]
NE	.2	.3	.6	[illegible]	.3	.4	.3		.1			[illegible]	[illegible]	[illegible]	[illegible]
ENE	.2	[illegible]	.4	[illegible]	.4	[illegible]	.2	.2				[illegible]	[illegible]	[illegible]	[illegible]
E	.1	[illegible]	.2	.1	.1	.1		.1				[illegible]	.7	[illegible]	[illegible]
ESE	.1	.3	[illegible]	.3								[illegible]	[illegible]	[illegible]	[illegible]
SE	.2	[illegible]	.1	.1	.1	.2						[illegible]	.6	[illegible]	[illegible]
SSE	.2	[illegible]	.2	[illegible]	.1	.2						[illegible]	[illegible]	[illegible]	[illegible]
S	[illegible]	.7	1.	[illegible]	.4	.1	.2	.3				41	4.3	[illegible]	[illegible]
SSW	.1	.7	[illegible]	[illegible]	1.3	[illegible]	.4	[illegible]	.2			[illegible]	[illegible]	[illegible]	[illegible]
SW	.3	[illegible]	[illegible]	[illegible]	1.7	[illegible]	[illegible]	[illegible]	.2			[illegible]	[illegible]	[illegible]	[illegible]
WSW	.2	1.5	[illegible]	[illegible]	2.2	[illegible]	1.2	1.7	.3			123	[illegible]	[illegible]	[illegible]
W	.2	2.2	[illegible]	[illegible]	2.7	[illegible]	2.3	[illegible]	.1			143	[illegible]	[illegible]	[illegible]
WNW	.2	[illegible]	[illegible]	1.3	1.6	2.1	1.2	1.3	.2			[illegible]	11.8	[illegible]	[illegible]
NW	.2	1.	[illegible]	1.6	1.2	[illegible]	2.0	1.7	.2			87	[illegible]	[illegible]	[illegible]
NNW	.1	.7	1.	.7	2.2	.7	1.0	.7	.4			79	[illegible]	[illegible]	47.3
CALM												3	.3		
TOTALS	[illegible]	135	166	[illegible]	145	110	113	95	19			[illegible]	--	[illegible]	43.[illegible]
PERCENT	.	14.1	17.3	16.4	15.[illegible]	11.5	11.8	10.1	2.0			-	100.0		
MEAN SPEED	[illegible]	15.2	28.7	34.4	44.3	56.6	65.5	[illegible]	111.7						

θ	V_r	σ_v	ΣXY	ΣV²	* $N\sigma_y/\Sigma X$	** σ_v/V_r	σ_a	σ_b	σ_s
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.44[illegible]	1.[illegible]	33.[illegible]	[illegible]	[illegible]
N	ΣX/N	σ_x	ΣX	ΣX²	* $N\sigma_x/\Sigma X$	** σ_v/σ_s	r	* ψ	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.[illegible]	1.[illegible]	.[illegible]	[illegible]	
	ΣY/N	σ_y	ΣY	ΣY²	* $N\sigma_y/\Sigma Y$	** $V_r/\bar{V}$	ΣV	$\bar{V}$	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

σ_x [illegible] deviation of east components
σ_y [illegible] deviation of north components
σ_v [illegible] vector deviation of wind velocity
r [illegible] coefficient of north and east components
[illegible] wind speed
[illegible] wind speed
[illegible]

σ_a Standard deviation of wind components along the major axis of the distribution
σ_b Standard deviation of wind components perpendicular to the major axis of the distribution
ψ Angle of rotation of the major axis of the wind distribution counter-clockwise from E-W direction
θ Resultant wind direction
V_r Resultant wind speed
σ_s Standard deviation of wind speeds
** [illegible]

CUSTOMER IDENTIFIED OPERATIONAL LIMITATIONS

The following weather threshold values have been identified by our customers as limiting factors to the operation of their aircrafts. Included in this section are:

1. Emergency and enroute alternates for WTD Aircrafts.

2. Limitations and weather thresholds for the KC-135 aircraft, as identified by the 34th Strategic Squadron (SAC).

3. Limitations ana weather thresholds for UH-1N aircrafts, as identified by Det 9, 67 ARRS.

4. Limitations and weather thresholds for 406 TFTW WTD aircrafts, as identified by the 406 TFTW/DO.

5. Limitations and weather thresholds for the C-5 aircrafts.

6. Other limiting factors.

EMERGENCY AND ENROUTE ALTERNATES FOR WTD AIRCRAFTS.

NOTE: A binder labeled "Cross Country Flimsy Flight Folder (CCFFF)" has been prepared, and contains emergency, primary, secondary, and other alternates, maps, runway headings and length, for use on obtaining required WTD deployment data.

The following list of aerodromes has been identified as primary emergency alternates by the 406th TFTW. Due to the nature of the supported aircrafts, the sparcity of suitable aerodromes and the European climate, emergency use of one of these alternates is always a distinct possibility. Runway headings are indicated in 10s of degrees magnetic. Length of runway is in hundreds of feet An asterisk denotes that the runway is barrier equipped.

STATION	ICAO	RUNWAY HEADING	LENGTH OF RUNWAY
SPAIN			
Torrejon	LETO	05/23	134 *
Valencia/Manises	LEVC	12/30	88 *
Madrid/Getafe	LEGT	05/23	87 *
GERMANY			
Ramstein	EDAR	09/27	80 *
Spangdahlem	EDAD	05/23	100 *
Hahn	EDAH	04/22	80 *
Bitburg	EDAB	06/24	82 *
Sembach	EDAS	07/25	79
Zweibruken	EDAM	03/21	79 *
Solingen	EDAL	04/22	81 *
Norvenich	EDNN	07/25	80 *
Bruggen	EDUR	09/27	81 *

ENGLAND

Mildenhall.................EGUN............11/29..............92 *
Alconbury..................EGWZ............12/30 ....90 *
Bentwaters.................EGVJ............07/25..............89 *
Lakenheath ....EGUL............06/24..............90 *

NETHERLANDS

Soesterberg................EHSB............09/27..............88 *
Leewarden.......... ....EHLW............09/27..............81 *
Twenth/Enscheded...........EHTW............06/24..............92 *

FRANCE

Strasbourg.................LFST............05/23..............79 *
Luxevil/St. Sauver.........LFSX............04/22..............79 *
Difon/Lonvic...............LFSD............18/36..............79 *
Lyon/Satolas...............LFLY............17/35..............60
Toulouse/Blagnac...........LFBO............15/33.............115

(2) TURBULENCE: Flights through known severe turbulence are not recommended and should be avoided, if at all possible. The forecaster will assist crews in flight planning if moderate or greater turbulence is forecasted for a route of flight. Aircraft awaiting the "wing reskin" program will make every attempt to avoid known/reported areas of moderate to severe turbulence.

(3) THUNDERSTORMS: Flights through thunderstorm activity, or known severe turbulence are not recommended and should be avoided if at all possible. Thunderstorms should be avoided by at least 20NM at or above FL230, or 10NM below FL230. Aircraft will not attempt to takeoff, land, nor approach if:

(a) Thunderstorm activity is affecting the airfield.

(b) The thunderstorm is expected to adversely affect the flight path.

2. SAC crews manually compute takeoff data. During mission planning, the co-pilot must have temperature, pressure altitude and forecasted runway condition (wet or dry), the day before the mission will be flown. KC-135 aircraft use two types of data for takeoff planning, Wet Thrust augmentation and Dry Thrust augmentation. The forecasted data must be within the following parameters, or the crews must re-accomplish the takeoff data computations:

a. WET THRUST COMPUTATION LIMITATIONS:

(1) Temperature ±10°F

(2) Pressure Altitude ±200 feet

b. DRY THRUST COMPUTATION LIMITATIONS:

(1) Temperature ±5°F

(2) Pressure Altitude ±200 feet

c. The crew MUST be briefed of the presence of any temperature inversions, especially when the climb out is to be marginal.

LIMITATIONS AND WEATHER THRESHOLDS FOR THE KC-135 AIRCRAFT

AS IDENTIFIED BY

THE 34th STRATEGIC SQUADRON (SAC)

1. The 34th Strategic Squadron (SAC), has identified the following as limitation and/or weather thresholds for the KC-135 aircraft operating from Zaragoza Air Base:

a. TAKEOFF MINIMUMS:

(1) No ceiling restrictions - RVR poses the only limitation. Higher headquarters directed missions = Visibility - RVR 1000 ft. All other SAC missions (excluding emergency missions) RVR 1600 ft.

(2) When the field is below approach and landing minimums, takeoffs are only authorized if a suitable alternate is within one hour distance at aircraft cruising speed. The minimums to qualify for a takeoff alternate: Operation published precision approach is better than 600 feet and 2 miles visibility (±1 hour of takeoff).

(3) Operational published non-precision - the field must be 800 feet and 2.0 miles visibility, or ceiling 500 feet and visibility one mile above the lowest published landing minimum, whichever is higher until one hour after possible ETA.

(4) Crosswind component 25 knots or less.

(5) SAC aircraft WILL NOT takeoff under conditions of freezing rain or freezing drizzle.

b. LANDING MINIMUMS:

(1) Precision approach - RVR 2400, or the published minimum for the approach, whichever is higher.

(2) DESIGNATION OF ALTERNATES: Filing to a destination at which Radar is the only available approach aid. Plus or minus one hour of ETA, the worst weather that is forecasted to be less than:

(a) Ceiling - 3000 feet

(b) Visibility - 3.0 miles or 2.0 miles more than the lowest landing minimum, whichever is greater.

c. INFLIGHT RESTRICTIONS:

(1) ICING:

(a) SAC aircrafts will not be flown for more than 10 minutes in moderate icing conditions.

(b) SAC Aircrafts will not be flown into known or suspected severe icing conditions.

LIMITATIONS AND WEATHER THRESHOLDS FOR UH-1N AIRCRAFT

Detachment 9, 67th ARRS has identified the following limitations and/or weather thresholds for the UH-1N aircraft that operate from Zaragoza Air Base.

(1) TRAINING SORTIES WEATHER MIMIMUMS:

(a) DAY VFR: Ceiling: 700 ft.
Visibility: 1.0NM

(b) NIGHT VFR: Ceiling 1,000 ft.
Visibility: 2.0NM

(c) IFR OPERATIONS: Ceiling and visibility must be equal to 1500 feet/4.3NM, but visibility NOT less than 0.5NM, or RVR 2400 feet.

(2) OPERATIONAL SORTIES WEATHER MINIMUMS:

(a) Visibility at the departure airfield must be equal to or higher than 0.2NM (with RADAR), if take off is made without an alternate.

(b) Visibility at the departure and the alternate airfield must be equal to, or higher than, 0.2NM (PAR approach), RVR 1200 feet.

(c) LIFE AND DEATH SAR MISSIONS: A helicopter may take off if the visibility is sufficient to taxi to the take off area.

(3) FILING REQUIREMENTS FOR TRAINING MISSIONS:

(a) IFR Flights, RVR 1200 feet or prevailing visibility 0.2NM (PAR APP) at the departure airfield. An alternate is NOT required.

(b) An alternate is required when the ceiling is less than 700 feet and/or visibility 1.0NM at the destination airfield.

(c) Alternate Weather Minimums: Ceiling at least 700 feet, and/or visibility 1.0NM, or 500 feet and 1/2 mile above lowest published minimums, whichever is the highest. The pilots must always know the worst condition forecasted.

(4) ICING CONDITIONS: Intentional flight through known icing conditions with OAT colder than minus 5 degrees Celcius is prohibited. The UH-1N helicopter is restricted from flight in icing conditions other than trace ice.

(5) THUNDERSTORMS: Flights may be made into areas of known or forecasted thunderstorms if VMC is maintained and thunderstorm activity is avoided by a minimum of 5NM.

(6) WIND RESTRICTIONS:

(a) Training sorties: 40 knots or a 20 knot spread.

(b) Operational sorties: 45 knots.

LIMITATIONS AND WEATHER THRESHOLDS
AFFECTING THE VARIOUS TYPES OF AIRCRAFT
THAT DEPLOY TO ZARAGOZA AIR BASE, FOR WTD OPERATIONS

The 406TFTW/DOV, identified the following limitations/thresholds for WTD aircraft deployed to Zaragoza Air Base:

1. CROSS WIND COMPONENTS:

(a) Max allowable

TYPE OF AIRCRAFT	DRY RUNWAY	WET RUNWAY
F-4E/G	25 knots	15 knots
F-4D	35 "	15 "
F-5	35 "	20 "
F-15	30 "	30 "
F-111E	35 "	35 "
OV-10	20 "	20 "

(b) OV-10 AIRCRAFTS: These aircrafts are not permitted to taxi anytime the wind component (including gusts) reaches 35 knots. OV-10 and F-5 aircraft can not cruise in icing conditions.

(c) F-4 AIRCRAFTS: Maximum allowable tail wind component for takeoff is 10 knots on a dry runway or 5 knots on a wet runway.

2. CEILING/VISIBILITY MINIMUMS: All USAFE aircraft listed above must have at least 1.0NM visibility (RVR55) and 300 feet ceiling for takeoff and landing, unless the Wing Commander waives weather requirements, in which case the weather must be at least 200 feet ceiling/visibility 0.4NM.

GENERAL WEATHER LIMITATION FOR MAC AIRCRAFT

(Extracted from AFR 60-16 and MAC Sup 1, Chapters 5 & 8)

1. ALTERNATES

a. Two alternates must be filed if the forecast visibility, prevailing or intermittent, is less than published for an available approach or the forecast surface winds, prevailing or intermittent, exceed limit, corrected or RCR.

b. Must be filed when destination is outside CONUS. EXCEPTION: If the destination is remote or an island its' forecast weather must meet the following restrictions:

(1) The prevailing surface winds corrected for RCR, must be within limits at ETA and remain so for two hours thereafter.

(2) The prevailing ceiling and vis are equal to or greater than published minimums for an available nonprecision approach (excluding ASR) for ETA plus two hours, if a precision approach is available, the ceiling or vis may be temporarily or intermittently below nonprecision approach minimums (excluding ASR) but not below precision approach minimums.

2. TAKE-OFF MINIMUMS

a. When available, RVR will be used to determine the minimum visibility required for take-off.

b. Take-off without a departure alternate may be made when existing weather conditions are equal to or above authorized landing minimums, to include ceiling and visibility.

c. Take-off with a departure alternate may be made when the existing runway visual range (RVR) is equal to or greater than RVR 16 or visibility one-fourth mile if RVR is not available. The departure alternate(s) will be selected using the following criteria:

(1) The existing weather at an alternate within 30 minutes flying time will be equal to-or-better than the published approach minimums and forecast to remain so for one hour after takeoff, but in no case forecast to be lower than 200-foot ceiling/RVR 24 (visibility 1/2 mile).

(2) The existing weather at an alternate within one hour' flying time for two-engine aircraft, or within two hours for four-engine aircraft, must be at least 500-1 above the lowest compatible published landing minimus, but in no case lower than 600-2 for a precision approach, and forecast to remain so for one hour after ETA at the alternate.

d. All aircraft except CT-39 may depart runways with operable centerline lighting and operable RVR display slave readouts for both approach and departure ends if the RVR at the approach end of the runway is equal to or greater than 12 and the RVR at the departure end of equal to or greater than 10. A take-off alternate is required.

3. LANDING/APPROACH MINIMUMS

a. As published unless full instrumentation not available, then, HAT (Height Above Touchdown) of 300 feet and RVR 40 or 3/4 of a mile if RVR not available.

b. For PAR approaches. HAT of no less than 200 feet and RVR 24 or 1/2 mile if RVR not available.

c. Circling approaches will use PV for determination of minimums. If minimums are not published by category the minimums altitude will be as published, but in no case lower than the value indicated below, plus the published airport elevation.

CAT A	400	Feet	one mile
CAT B	500	"	" "
CAT C	500	"	one 1/2 miles
CAT D & E	600	"	two miles

d. Except for circling approaches - use RVR, RVV and PV in that order to determine if visibility is at or above published minimums.

4. GENERAL RESTRICTIONS

a. Maximum crosswind component of 25 knots, may be less depending on RCR and landing gross weight. Maximum tail wind - 10 knots; headwind - 50 kts.

b. Aircraft will not be operated into areas of known or forecast severe icing or turbulence.

c. Avoid thunderstorm and cumulonimbus clouds using the following criteria:

(1) Climbout - Enroute-Desent

(a) FL 230 and above - 20NM

(b) Below FL 230 - 10NM

(c) Tactical operation: Below 230 - 5NM. Outside air temperature must be above 0°C.

(d) Avove criteria must be determined visually.

(2) Take-off and landing may be made with less than the criteria listed above, provided:

(a) The thunderstorm or CB's and associated gust front if present, can be avoided.

(b) From lift-off, the distance from the thunderstorm or CB's is increased as soon as possible to meet the criteria in (1) above.

(c) A missed approach course from the missed approach point is available which will provide separation similar to that for departures.

(d) The aircraft is not flown below thunderstorms, CB's or through the rain shift associated with these clouds.

d. C-5 air refueling missions will not be launched if severe turbulence is forecast on the refueling track.

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LIMITATIONS AND WEATHER THRESHOLDS FOR THE C-5 AIRCRAFT

1. A local source for obtaining this information was not available. This information was extracted from the C-5 Dash-1.

a. ICING: The C-5 Dash-1 states "Under no circumstance will flights be planned through forecast or known severe icing conditions. Aircraft operations in moderate icing conditions may be tolerated for short periods of time (climb or descent), but evasive action (change altitude, course or airspeed) should be undertaken to exit the icing conditions as soon as possible."

b. TURBULENCE/THUNDERSTORM LIMITATIONS: The C-5 Dash-1 states "Flights through thunderstorms or other areas of turbulence should be avoided whenever possible. Maximum use of radar and weather forecast facilities is essential. All C-5 aircrafts must be flown in a special aileron upright configuration to reduce stress on critical wing structures whenever turbulence of any intensity is encountered. The aircraft uses more fuel in this configuration, so observations and forecasts of even light turbulence are significant. C-5 cannot air refuel when in an area of forecast severe turbulence or observed moderate turbulence or whenever the visibility is 1.0NM or less.

c. FREEZING PRECIPITATION: Any intensity may be prohibitive because of the magnitude of the deicing process. Forecasts of freezing precipitation at any point during scheduled ground times are an important consideration and MUST BE BRIEFED.

d. TAKEOFF AND LANDING CRITERIA: Ceiling of 200 feet and/or visibility of 0.5NM and/or RVR50. However, if there is a suitable takeoff alternate, takeoff with visibility of 0.25NM and/or RVR16 may be authorized. Landing minimums are ceiling 300 feet and/or visibility 0.6 or RVR40.

e. TEMPERATURE RESTRICTIONS: The takeoff performance of the C-5 aircraft is dependent upon the temperature profile in the lower 2,000 feet AGL. When temperature increases markedly (in an inversion) with altitude, aircraft performance is adversely affected and may become critical when the aircraft is operating near maximum gross weight.

2. NOTE: All of the above factors must be considered when preparing a briefing for this type of aircraft, and if forecasted, must be specifically briefed to the aircrews.

LIMITATIONS AND WEATHER THRESHOLDS FOR
THE VARIOUS WTD TRAINING AREAS

The 406TFTW/DO, has identified the following thresholds as limiting factors of the various areas used for WTD operations.

1. LED 50:

a. TRAINING ACTIVITIES: Air to Surface tactics and gunnery practice low level navigation.

b. FLIGHT LEVEL: Surface to FL 150, with primary operations from surface to FL080. Area may be entered at any altitude if VMC.

c. Minimum weather conditions required are ceiling/visibility 3000/3.0NM.

2. SECTORS (ACRO):

a. TRAINING ACTIVITIES: Transition (acrobatics, confidence maneuvers, stalls, advanced handling), Intercepts, Air Combat Training.

b. FLIGHT LEVELS: FL070 to FL200. Entry and exit at any altitude VMC. VMC operations only.

c. INTERCEPTS: Required minimum ceiling of 4000 feet or better.

(1) Basic fighter maneuvers require varying amounts of airspace with a minimum of approximately a 6000 feet block.

(2) Air combat tactics require enough clear airspace to maneuver and maintain 2000 feet from clouds. Transition requires a clear airspace from approximately FL150 to FL190 in order to initiate confidence maneuvers and stalls above FL170.

3. LED 21:

a. TRAINING ACTIVITIES: Air combat training, air to surface tactics and gunnery.

b. FLIGHT LEVEL: Surface to unlimited. Area can be entered at any flight level.

c. AIRSPACE REQUIREMENTS: For air-to-air are the same as for the sectors. Weather requirements for air-to-surface are ceiling/visibility 3000 feet/3.0NM, but for LASER operations, a ceiling of 5000 or better is desired.

4. LED 101:

a. TRAINING ACTIVITIES: Air combat training, and intercepts.

b. FLIGHT LEVELS: FL100 to FL400. Area may be entered and exited at any altitude VMC.

c. AIRSPACE REQUIREMENTS: These are the same as the sectors.

5. LED 89:

a. TRAINING ACTIVITIES: Dart firing.

b. FLIGHT LEVELS: 1000MSL to unlimited. The area is normally entered on an IFR clearance at FL250 and exited at FL260. Flights may enter VMC under VFR at any altitude if necessary for mission accomplishment.

c. RESTRICTIONS: An undercast below approximately FL150 or low broken deck, which would preclude clearing the sea for shipping, will prevent firing. Normal working altitudes are between FL100 and FL250. A minimum of approximately 7000 feet clear airspace is needed to fire.

LIMITATIONS AND WEATHER THRESHOLDS
U.S. ARMY AIRCRAFT PRESENTLY OPERATING IN EUROPE

This information was provided by 31WS/DOT, in a letter dated 25 February 1980, from information compiled by 7WS, indicating all the known limitations for U.S. Army aircrafts presently operating in Europe.

LIMITATIONS	C-12/U-21	UH-1	AH-1	OH-58	CH-47
Sustained wind at the surface	(1)	30 knots (start)	30 knots (start)	20knots (auto-rotation) 45knots (start)	30knots (start)
GUST SPREAD	(1)	15knots (start	15knots (start)	10knots (auto-rotation) 15knots (start)	
TAIL WIND	(1)	30knots (hover)	30knots (hover)		25knots (start) 10knots (start w/o auxillary power cart)
CROSS WIND	(1)	35knots (hover)	35knots (hover)	10knots(auto-rotation	
ICING	SEVERE	LIGHT (Can IF CIG IS ≤010, TOPS ≤080 and IN/OUT	CAN'T FLY IN ANY ICE (NO IFR)	CAN'T FLY IN ANY ICE (NO IFR)	SEVERE
TURBULENCE (3)	SEVERE (2)	SEVERE (2)	SEVERE (2)	SEVERE	SEVERE

NOTES: a. Aircraft Dash-10 TM used for reference in compiling this data.

(1) Limitations for these aircraft vary according to the experience level of the pilot and various other factors. It is not possible to list all combinations.

(2) Moderate turbulence limitations are:

(a) Prohibited when the report or forecast is based on transport type aircraft.

(b) Permitted when the report or forecast is based on helicopters or light aircraft under 12,500 pounds gross weight.

(3) Helicopter operations are permitted or prohibited based on the source of the report of moderate or greater turbulence.

(4) DOD FLIPS cover the weather minimum at each airfield.

OTHER LIMITING FACTORS AFFECTING AIRCRAFT OPERATIONS IN EUROPE

The following are known limiting factors that affect aircraft operations in Europe, and that should be considered by the forecasters.

UNIQUE WEATHER PROBLEM AT AVIANO AIR BASE, ITALY: The following was extracted from the "FLIP General Planning Guide":

"1. AVIANO AB - All aircrews note hazards of winter weather conditions and pre-flight planning procedures required below:

a. Normally, Aviano weather is good while nearby airfields experience low visibility conditions caused by fog and haze. Slight changes in wind direction can cause these same conditions at Aviano and the nearest suitable alternates are as much as 200 NM away. Since all alternates for Aviano are non-USAFE aerodromes, appropriate weather minimums apply. Pre-flight planning should include a thorough check of all aerodromes in Northern Italy; and, if any doubt exists, prior to your departure, call Aviano Command Post for the latest information. Also, when approaching Aviano, call METRO or Command Post for local conditions.

b. Italy has no radar for controlling enroute air traffic. ATC centers use procedural or conventional control and the spacing of aircra[illegible]s accomplished by vertical and lateral sepa[illegible] pilot reports. Aviano approach control uses conventional control and has very limited airspace. Aviano GCA can handle a maximum of four aircraft at one time and, during peak traffic periods, delays of up to 30 minutes can be expected.

c. Additionally, due to problems concerning the proper routing of light planes, especially if filing from a non-USAFE aerodrome or from a remote, seldom

used aerodrome, ATC does not receive sufficient advance notice of aircraft arrival. This further complicates the traffic situation and results in "untimely delays."

SECTION III

APPROVED FORECAST STUDIES

(There are no approved Forecast Studies at Zaragoza AB - there is one inconclusive retired study on winds, available at the forecast counter)

FORECAST PROBLEMS

AT

ZARAGOZA AIR BASE

ARE

Dense persistant winter fog

High surface winds

Thunderstorms and associated phenomena

(RULES OF THUMB: There are no approved Rules of Thumb. However, there are on-going investigations and research of specific relationships and parameters which could subsequently result in Rules of Thumb.)

FORECAST PROBLEMS

AT

BARDENAS REALES GUNNERY RANGE

ARE

Thunderstorms and their associated phenomena

Early morning for and/or low ceilings

(RULES OF THUMB: There are no approved ROT for the range, nor any under development.)

RULES OF THUMB

1. As of the date this TFRN was complied, there were no approved Rules of Thumb nor approved Forecast Studies available for Zaragoza Air Base, nor for Bardenas Reales Gunnery Range.

2. Several investigations were being conducted, seeking methods to improve our ability to forecast wind, fog, and thunderstorms:

a. WIND INVESTIGATION: This was on its second year of evaluation. Some valid parameters have been found, but must be tested further to verify their reliability.

b. FOG INVESTIGATION: Completed; however, it was inconclusive and concluded with a recommendation for further investigation of other parameters than the ones that were evaluated. This will be done in the fog season of 1980-1981.

c. THUNDERSTORMS: This investigation concluded that the only method of improving our ability to forecast thunderstorms would be to install a Rawindsonde unit at Zaragoza Air Base. The thunderstorm investigation also includes data from a previously conducted study (1958 to 1959), which does point out specific parameters that can be used as indicators for storm activities at Zaragoza Air Base. We have included a Radar investigation that was also inconclusive in forecasting storm activities in the Ebro Valley.

3. Commander's Comment (1980): The basic problem in conducting a research project/study at Zaragoza Air Base, Spain is the unavailability of reliable and meaningful data representative of the surface and upper level controls in/and about Zaragoza Air Base.

WIND FORECAST INVESTIGATION

AT ZARAGOZA AIR BASE, SPAIN

By: MSgt Domingo Fernandez
Det 16, 31WS, Forecaster
5 February 1979

WIND FORECAST INVESTIGATION

MWA OR PWW CRITERIA

1. Problem: Forecasting Surface Winds at Zaragoza AB.

2. Discussion:

a. Forecasting wind for Zaragoza is a function of pressure gradient in the Ebro Valley, thermal advection, and the Venturi effect caused by the Ebro Valley. These parameters were investigated by a study that was conducted from 1971 to 1975. A forecasting technique was developed using the difference in pressure from Santander (LEXJ) and Barcelona (LEBL):

$3[\Delta P(LEXJ - LEBL)]$ = Average Wind Speed

$3[\Delta P(LEXJ - LEBL)] + 10$ = Peak Wind

The technique provides a fairly accurate peak wind forecast but is limited to Δ P values between 5 mb and 12 mb. Below 5 mb, surface winds observed are not significant and above 12 mb, the technique looses its accuracy.

b. The following parameters and relationships are considered when forecasting surface winds at Zaragoza. These parameters were tested and found to be useful by the 1971 - 1975 study:

(1) The overall Ebro Valley gradient is important only when High pressure is centered in the North-Central part of the Bay of Biscay. Under this condition, Zaragoza is subject to strong surface wind from the Northwest (330°), and the above technique works quite well in forecasting peak wind speed, as long as the gradient is less than 12 mbs.

(a) When a High is centered in the South or Southeastern portions of the Bay of Biscay, the gradient up-the-valley from Zaragoza (LEZG) to Santander (LEXJ), as well as the down-the-valley gradient from Zaragoza (LEZG) to Barcelona (BL), are of equal importance.

(b) When the down-the-valley gradient is predominant, LEXJ - LEZG > LEBL - LEZG, the wind direction should be from the Northwest and the peak gust may be computed using the above formula.

(2) When Zaragoza registers the highest pressure in the valley and Barcelona the lowest but Torrejon (LETO) is 2 to 4 millibars higher than Zaragoza, strong westerly surface winds should be forecast at Zaragoza. The technique may be adjusted to forecast peak wind speed and direction but it is not documented if the 12 mb limitation applies.

Direction: P = LETO - LEZG > 2 to 4 mbs: forecast westerly wind

$3 \times [\Delta P = LEZG - LEBL \geq 5 \text{ mb} < 12 \text{ mb}] + 10$ give average wind and peak gust

3. Limitations: In all cases when ΔP exceeds 12 mb, the recorded speed and max gust have not occurred as per this technique.

4. Comments:

a. Results of the 1971 study infer that the 500 mb wind direction plays an important role on surface wind speed and direction. At the end of 1972, the study indicated the following condition for surface wind forecasts:

(1) The 500 mb wind direction from 270 to 040 degrees reinforces the Northwest wind direction at the surface.

(2) The 500 mb wind direction from 041 to 269 degrees reinforces the Southeast wind direction at the surface.

b. Based on Det 16 forecasters' experiences since 1974 till present, the occurrence of cold advection at levels below 500 mb seems to play a significant role.

c. Both paragraphs a and b above introduce large individual subjective errors since we do not have an objective technique to either record or forecast 500 mb wind and/or the occurrence of thermal advection at levels below 500 mb. For information purposes, even though Rawinsonde data is supposed to be available twice daily from La Coruña and Barajas Airport, the availability of this data is so sporadic that it cannot be relied upon. However, it could be possible to interpolate/extrapolate the 500 mb wind speed and direction from the daily hand plotted 500 mb chart analysis and use this as an approximation or quantified indication of cold advection. Also the trajectory forecasts could be looked at as indicators of whether or not cold advection should be considered on a particular day.

5. Recommendation: The following parameters should be evaluated for an initial 90 day period - 15 Feb through 15 May 79, to coincide with the start of the windy season. If a relationship is found, then continue the evaluation through 15 Sep 79 to compile a reliable data base for possible modifications to the wind forecasting technique. The following parameters and relationships should be evaluated:

a. ΔP = LEXJ - LEBL, ΔP = LEXJ - LEZG, ΔP = LEZG - LEBL, ΔP = LETO - LEZG.

b. 500 mb wind direction. 270 to 040 for support of strong surface wind speeds, and Northwest direction.

c. 500 mb wind direction. 041 to 269 indicative of reinforcement for forecasting Southeast surface wind direction.

d. The validity of the Δ P technique when strong surface overall-valley-gradient and a 500 mb wind direction from other than 270 to 040 degrees occur.

e. 500 mb wind speed in increments of 0 - 20 kts, 20 - 40 Kts, > 40 kts and its relationship to surface wind speed and direction.

1 Atch
Wind Investigation Workchart

WIND INVESTIGATION

PRESSURE (PPP)				DATE:		
STATION	00	03	06	09	12	15
08023						
08160						
08181						
08221						

NOTE: 1. If station 08023 is not available, enter 08022 or 08024.
2. If station 08181 is not available, enter 08180 or 08176.
3. When stations 08022, 08024, 08180 or 08176 is/are used, so indicate in the PPP block(s).

	00	03	06	09	12	15
ΔP LEXJ-LEZG						
ΔP LEZG-LEBL						
ΔP LEXJ-LEBL						
ΔP LETO-LEZG						

500 MB

500 MB WND DRCTN/SPEED EXTRAPOLATED FROM 00Z AND 12Z RAOBS, LAFP, OR UPPER LEVEL WND FAX CHARTS. FOR 06Z/18Z, USE FAX CHART, IF AVAILABLE.

00Z ________/________ 06Z ________/________

12Z ________/________ 18Z ________/________

FCSTD WND AT LEZA

0500Z ________________ 1100Z ________________

WIND MWA or PWW ISSUED: Yes/No

VT: ________________

WND DRCTN/SPEED ________________

MAX WND OBSERVED: ________________ ________________
DRCTN/SPEED TIME

WIND INVESTIGATION, 60 DAYS REPORT

1. A wind investigation was conducted from 20 February 1979 to 20 April 1979. After evaluating the 60 days of data, the following information was derived.

a. The locally devised formula for wind max speed computation, $3\Delta P(LEXJ - LEBL) + 10$, seems to be very accurate for forecasting "strong" surface wind for Zaragoza; however, the previously identified 12 mb limitation still exists, and a solution to the limitation cannot be found.

b. The 500 mb wind direction from 270 to 040 degrees does seem to reinforce strong northwesterly surface wind; however, a subjective value of 500 mb thermal advection "into the Ebro Valley" must be considered before forecasting "strong" surface wind at Zaragoza AB. The following should be used as guidance:

(1) Strong "cold thermal advection" (e.g. 500 mb isotherms close to 90° from the 500 mb isogons (equal wind direction), gives a high probability of strong surface wind and strengthens the values derived from the ΔP formula in part a above.

(2) Warm thermal advection at 500mb, cold advection at lower level: This situation causes strong surface wind, and the ΔP formula can be used with a high degree of confidence, since it is quite accurate under this condition.

(3) Strong warm thermal advection (500 mb isotherms are 90° from the 500 mb isogons, with "warmer" air being "pushed" towards the Ebro Valley): When warm advection is also present at lower levels, care must be taken when using the value obtained from the ΔP formula, generally, the value obtained is too high. A "strong valley gradient" by itself is not sufficient to forecast "strong" surface wind when this condition exists; and other causes must exist (FROPA, Trough, etc.), to cause strong surface wind in the Ebro Valley. The overall valley gradient (ΔP from the formula) can be used to forecast the surface wind, but it must be adjusted downward; once again, subjectively, since no set pattern can be determined.

(4) Neutral thermal advection at 500 mb (500 mb isotherms are parallel to the 500 mb isogons):

(a) If the advection is neutral from the surface to 500 mb the ΔP formula will tend to overforecast the speed, and the derived value must be adjusted downward.

(b) Neutral advection at 500 mb, warm advection at lower level: The surface wind will not be strong and the ΔP formula will overforecast wind speed.

(c) Neutral advection at 500 mb, with cold advection at lower levels (in particular, cold advection at 850 mb): Forecast strong surface wind, and the ΔP formula is very accurate in forecasting wind speeds up to 46 knots.

(5) When the 500 mb isogons are orientated from 050 to 260 this opposes "strong" surface wind in the Ebro Valley; however, the 500 mb isogons from 050 to "E" and "SE", with "cold" thermal advection "into" the LEZG to LEBL pressure gradient is more than 4 mb, but less that 12 mb. However, <u>when the gradient is greater than 12 mb, the ΔP formula does not accurately forecast any wind speed</u>.

<u>NOTE</u>: There <u>does not</u> seem to be much correlation between a strong surface wind speed and any particular wind speed at upper levels. During the 60 days of this investigation, many occasions were observed of strong 500 mb wind speed (one case of 60 knots); yet the surface wind maintained a speed below 24 knots. The inverse was also true. We had cases of weak 500 mb wind speeds (one case down to 20 knots) with surface wind speeds up to 43 knots. However, it is logical to recommend that when the wind speed at upper levels begins to increase above 25 to 30 knots, one should expect a subsequent increase in the surface wind speed.

2. During the 60 day investigation, the following points were noted (even though these points were not being investigated) which are of meteorological interest:

a. If the surface wind speed at 0500Z is reported as 8 to 10 knots, there exists a 75% probability that the surface wind speed <u>will not</u> be stronger than 24 knots at any time during the day.

b. On most days that the 500 mb wind direction was from 050 to 260, a fact that tends to reinforce a "SE" wind in the Ebro Valley, Zaragoza AB will most likely be IFR (1500/4.3) within a couple of hours after sunrise.

3. Recommendations:

a. That ΔP formula be used as a rule of thumb (ROT) for computing the surface wind speeds but that consideration be always given to "thermal advection" into the valley before a forecast is made of strong surface wind.

b. That the TAF worksheet be modified to show the information on Attachment 1, and that on days that conditions favor strong surface winds the calculations be completed before any wind forecasts are issued.

DOMINGO A. FERNANDEZ, MSgt, USAF
Forecaster

1 Atch
P Computation

P COMPUTATION

DATE/TIME OF DATA:

STATION	PPP	APP		ΔP COMP GRADIENT
08023			08023 - 08160	$\pm$
08160			08160 - 08181	$\pm$
08181			08023 - 08181	$\pm$
08221			80221 - 08160	$\pm$

$$\Delta P = 3\,(\underset{08023}{\underline{\qquad}} - \underset{09181}{\underline{\qquad}}) + 10 + \underline{\qquad\qquad}$$

DECISION LOGIC TABLE

850 MB

	YES	NC
Warm Advection	Adjust speed downward	See cold advection
Cold Advection	Reinforce the ΔP formula	Adjust speed downward
Neutral Advection	Seek other causes for strong surface winds	

500 MB

	YES	NO
Warm Advection	See 850 mb Advection	Seek other causes
Cold Advection	Reinforce the ΔP formula	Adjust the speed downward
Neutral Advection	See the 850 mb advection	

Consider the following parameters:

1. A 500 mb wind direction from 270 to 050, with cold thermal advection into the Ebro Valley, will reinforce "NW" wind in the Ebro Valley.
2. "Strong" cold thermal advection into the Ebro Valley will reinforce the speed computed by the ΔP formula.
3. "Warm" thermal advection at all levels cause the ΔP formula to over forecast the surface wind speed.
4. 500 mb wind directions 050 to "SE", with cold thermal advection reinforces the speed computed by the ΔP formula.
5. When the 500 mb isogons are paralled to the 500 mb isotherms, the ΔP formula tends to overforecast the surface wind speed.

INVESTIGATION ON THE OCCURRANCE OF VISIBILITY RESTRICTIONS AT ZARAGOZA AB, SPAIN AND ASSOCIATED FORECASTING PROBLEMS

by: TSgt Rickey M. Reichert
Forecaster
Det 16, 'lWS

1. Statement of the Problem: The prediction of visibility restrictions at Zaragoza AB is nearly academic. The problem lies in two areas:

- the ability to forecast a wind shift under light and variable wind conditions.

- the ability to forecast how dense the restriction will be and the rate and time of dissipation.

2. Discussion:

a. Visibility restrictions of concern at Zaragoza AB are of two types: fog and haze. The most important consideration in forecasting visibility restrictions is the ability to correctly forecast the wind direction and speed that results into an easterly drift. Zaragoza AB lies approximately in the center of the Ebro Valley. The valley extends from near the city of Santander in the North Coast of Spain, station LEXJ, southeastward to near the city of Barcelona in the Mediterranean, station LEBL. Thus, the surface winds are nearly always dependent on the pressure gradient distribution within the valley e.g. down the valley gradient equates to a northwest surface wind and an up the valley gradient results in a southeast surface wind. It follows that the wind speed is directly related to the magnitude and direction of the pressure gradient. As the city of Zaragoza, the Ebro River, and several irrigation canals lie to the southeast of the base, a northwest wind will keep both fog, which forms over the waterways, and industrial pollution away from the base/runway complex. On the other hand, a southeasterly wind will blow it over. Very often, the early morning surface wind will be light and variable from the northwest and suddenly shift to an easterly direction between 0500Z - 0800Z. Thus, the capability to forecast this wind shift must be inherent in any investigation to improve forecasting visibility restrictions at Zaragoza AB.

b. Upper Air. Since there is no RAOB from Zaragoza, the presence and extent of any inversions as well as the 850 mb flow must be crudely estimated using unrepresentative RAOBs from Torrejon, or La Coruna in Spain or Biarritz, France, when available. These RAOBs may be used to detect cooling aloft which would cause any inversion present to break. Additionally, PIBALs available from Bardenas Reales Range are helpful in estimating winds aloft over Zaragoza. Also, the trajectory bulletin may be used to determine low level upward or downward motion, that is cold or warm air advection into the area.

Note: A fog investigation using the 850 mb trajectory forecast was accomplished in 1975. The investigation showed that the trajectory forecast is not a reliable parameter to predict the occurrence of fog in the Ebro Valley and at Zaragoza AB.

3. Parameters to be Evaluated for Forecasting Fog:

a. Current or forecast (0500Z - 0800Z) pressure gradient (ΔP) to the nearest 0.1 mb:

LEXJ (Santander) - LEBL (Barcelona) $\leq \pm 4$ mb

A postive gradient indicates down the valley flow; a negative value indicates up the valley flow. (Check ΔP LEXJ - LEZG (Zaragoza) for indication of possible visibility restrictions at Bardenas Reales.)

(1) A negative ΔP value up the valley flow (current or forecast) results in lower visibilities than a weak down the valley flow.

(2) With up the valley flow (current or forecast 0500Z - 0800Z) and the absolute value of $\Delta P \geq 5.0$ mb, wind speeds >10 knots result. In this case, the fog may stratify into a low ceiling (around 800 ft) and the visibility will not be as low as it normally would be.

b. Current or forecast (0500Z - 0800Z) temperature/dew point spread $\leq 2^{o}C$ and temperature $\leq 5^{o}C$, fog should form. If the temperature/dew point spread is $\geq 3^{o}C$ and the temperature is $> 5^{o}C$, haze instead of fog should form.

c. Occurrence of fog, haze and/or precipitation within the last 24 hours: If a change in air mass does not occur and is not forecast to occur within the preceeding 24 hours of the forecast and if fog, haze and/or precipitation occur within the preceeding 24 hours, the restriction will most likely reoccur because of available moisture.

d. Sky cover. Current or forecast clear skies at night result in strong radiational cooling. Under these conditions, at first light (just at sunrise) low level mixing occurs and a visibility restriction develops.

4. Evaluating Parameters: The following procedures should be used to evaluate the parameters in paragraph 3 above as effective tools in adjusting or developing visibility restrictions forecasting techniques.

a. If parameter 3a indicates a light and variable wind from any direction or easterly wind 10 knots from 0000Z to 0800Z (emphasis on 0500Z to 0800Z) and parameters C and D favor a visibility restriction then evaluate parameter B and forecast as follows:

(1) Parameter B strongly indicates fog: forecast less than 1.0 NM visibility.

(2) Parameter B strongly indicates haze: forecast 2.0 - 3.0 NM visibility.

NOTE: Adjust forecast visibilities when parameter values do not indicate a strong occurrence of a visibility restriction.

5. <u>Specific Purpose of Investigation</u>:

a. Within this context, the purpose of this investigation is to determine if any correlation exists between minimum visibility, minimum temperature and temperature/dewpoint spread under three different wind regimes.

b. At this time I feel the best way to serve our customers is by trying to develop a set of parameters that could allow us to more accurately forecast the minimum visibility during the morning hours. An attempt to improve the forecasting of on-set and dissipation times does not appear feasible due to the critical element of wind speed and direction within the valley.

6. <u>Data Collecting</u>:

a. The attached scatter charts will show correlation between minimum temperature, on the horizontal, and minimum visibility, on the vertical, by color coded dots representing temperature/dewpoint spread. Observed data will be plotted on the applicable chart to depict our three most predominatent wind regimes.

b. After a representative sample has been plotted a trend line will be drawn on the scatter charts to show the most probable minimum visibility of the morning using a forecasted minimum temperature, temperature/dewpoint spread and wind speed and direction.

c. If a good fog regime develops early, a preliminary series of charts will be prepared by 15 December 1979. Final analysis will be during February 1980.

d. The scatter chart, Attachment 1 is recommended to record and collect data for the investigation.

FOG INVESTIGATION AT ZARAGOZA AIR BASE, SPAIN

SUMMARY

1. Data for this investigation was collected and plotted from 1 October 1979 through 31 March 1980, using the guidelines set forth in the original investigation package.

2. Parameters tracked and their effects on the minimum visibility during the morning hours are as follows:

a. Minimum temperature: No trend could be established, as there were days with heavy fog (VIS 1.0) with temperatures ranging from 14°C down to -3°C. The most occurrences of heavy fog were observed on those days with a minimum morning temperature near 0°C.

b. Temperature/dew point spread: The scatter chart did show one interesting trend. We did not record any visibility below 3.0NM (AWS Cat D) with a temperature/due point spread of 3°C or greater. It appears reasonable to assume a visibility of less than 3.0NM (AWS Cat C and below) should not be forecasted when Zaragoza Air Base does not have, or forecasted to have, a temperature/dew point spread of 2°C or less. This in not to say, however, that when a temperature/dew point spread of 2°C or less is present, or forecasted, that the visibility will always decrease to below 3.0NM - it will not.

c. WIND: All visibility restrictions to less than 3.0NM were recorded on the scatter chart for winds from any direction, speed of less than 10 knots. Light and variable or Southeast winds were the most favorable for fog formation.

3. SUMMARY: In general, the scatter chart showed that there were days with almost identical parameters, with strongly indicated heavy fog (VIS less than 1.0NM); yet, while some days did indeed develop heavy fog, others produced only light mist or haze with visibility at or near 4.3NM. At this time, I feel that the key to more effectively forecast morning Fog at Zaragoza Air Base lies in knowing the characteristics (stability moisture, and wind direction and speed) of the first few thousand feet of the atmosphere over us. As we must crudely estimate this critical data from a RAOB from Madrid (a mountain station 120NM Southwest) and La Coruna (a coastal station 600 miles to the Northwest), our ability to forecast morning fog suffers.

4. RECOMMENDATIONS:

a. The ideal recommendation would be to install a Rawindsonde unit at Zaragoza Air Base. A sounding for Zaragoza would not only greatly enhance our ability to forecast fog, but also improve our ability to forecast icing, turbulence, cloud coverage and severe weather not only for the Zaragoza Air Base area but also for the Bardenas Reales Gunnery Range.

b. In the coming fog season (fall-winter 81), we may want to try breaking the scatter chart down into three (3) wind directions with speed of less than 10 knots, e.g., 041° to 160°, 161° to 280°, and 281° to 040°

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TERMINAL FORECAST REFERENCE NOTEBOOK(TFRN) ZARAGOZA AB, SPAIN A--ETC(U
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UNCLASSIFIED 2WW/TFRN-81/002 SBIE-AD-E850 053 NL

2 OF 2
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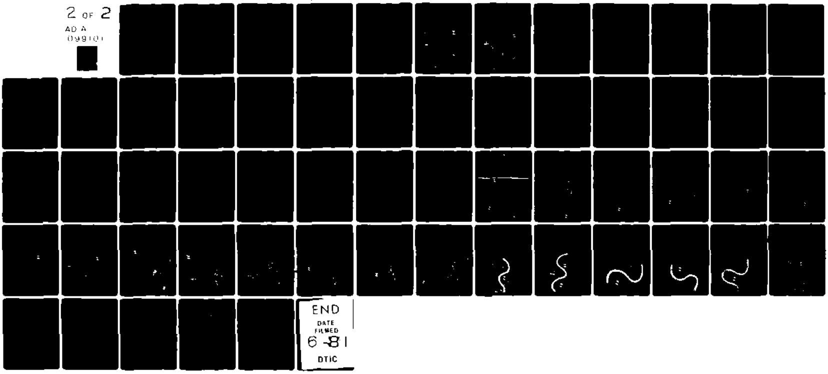


c. We should also continue to verify temperature/dew point spreads of 3°C or greater, that produce visibility of 3.0NM or greater.

THUNDERSTORM INVESTIGATIONS

(Summary of 1958-1959 Case File and summary supported by data collected and evaluated during the 1979 thunderstorm season)

By: TSgt Rickey Reichert

THE FORMATION OF AIRMASS THUNDERSTORM ACTIVITY AT ZARAGOZA AIR BASE

1. The primary threat of airmass thunderstorm activity exists at Zaragoza Air Base from May through September, and this threat normally is associated with southwesterly flow aloft, and generally after that pattern has existed for 24 to 36 hours. The pattern is also usually accompanied by sufficient low level moisture that is advected into the area by southeasterly flow at the surface, good surface heating and/or mechanical lifting.

a. The wind pattern from the surface to 5000 feet preceeding these storms is generally southeasterly, with occasional cases of light westerly or southwesterly flow.

b. Many days have been observed with the formation of cumulonimbus type clouds in the area and these clouds do not affect the base, but do constitute a threat to local flying activities.

(1) On some occasions with the presence of CB activity in the area, the upper level flow varies from southeasterly to westerly, in most cases being 20 knots or less. A two year case study (1958 and 1959), showed only one occurrence of northwesterly winds aloft and that caused thunderstorm activity over the base itself. It is suspected that this occurrence was associated with a minor upper level trough.

(2) Northeasterly flow aloft brought CB activity to the local area on two occasions during 1958 to 1959, with one occurrence of thunderstorm activity at the base itself. It was found that this instance was associated with an upper level low pressure center in the Mediterranean sea, centered east of the Balearic Islands. In the case of the thunderstorm over the base, the wind speed at 500 MB exceeded 35 knots.

c. The surface temperature preceeding thunderstorm activity at the base will, in most cases, be 2 to 5 degrees less than the convective temperature (extrapolated from the LEMD RAOB). Additional lift necessary to trigger the storm apparently is produced by the mountainous terrain that surrounds the base.

d. The stability index should average less than +4; although this is not an indicator that a thunderstorm will occur, it is specially useful in indicating severity, as in the case of hail at the surface. A stability of less than +1 has been the rule for hail occurrence at Zaragoza.

e. The moisture content of the air mass, as shown by available upper air soundings, may at times seem relatively dry, but this is misleading in forecasting thunderstorms in the local area. During 1958 - 1959, the average moisture indicated by available soundings showed temperature/dewpoint spreads at 5,000 feet = 9°, 10,000 feet = 6°, 20,000 feet = 9°.

2. SUMMARY: The ideal for airmass thunderstorm activity at Zaragoza Air Base is southeasterly winds from the surface to 5,000 feet (to bring in the required moisture), constant southwesterly flow aloft for a period of 24 to 36 hours with wind speeds at upper levels of greater than 20 knots, and a Showalter stability index of less than +4.

3. Parameters investigated: All RAOB data taken from 00Z data.

a. 500 mb wind (speed & direction) from LEMD RAOB 08221 and one up-stream station (USS) i.e., Lisbon 08536 or LECO 08001 or LFBD 07510 or LXGB 08495 or LEPA 08302.

b. Average surface wind for the Ebro Valley in the past 24 hours as well as the forecast wind for the next 24 hours (as this will be a "after-the-fact" investigation), the total 48 hour wind will be that observed.

c. TT/TD spread of 08221 and one up-stream station at the 850 mb level.

d. K Value for 08221 and one up-stream station (850 mb temp - 500 temp) + (850DP) - (700DP depression).

e. Totals Totals for 08221 and one up-stream station TT = (850 temp) - (500 temp) + (850DP) - (500 temp).

f. 850, 700, 500 Vertical Motion taken from the 00Z LEZA trajectory bulletin.

3 Atch
1. Data Collection Sheet
2. Typical Metrological Situation for Airmass Thunderstorms
3. Typical Metrological Situation for Frontal Thunderstorms

DATA COLLECTION SHEET USED

DATE ________________

1. 500 mb WND: 08221 ______________, USS(S) _______ ____________,

_______ ______________.

2. Average SFC WND 24 hrs before and after 05Z:

   24 before __________ 24 __________.

3. 850 TT/TD spread: 08221 __________, USS(S) _____ ____________,

_______ ______________.

4. K Value: 08221 ________, USS(S) ________ ______________,

________ ____________.

5. TT Index: 08221 _________, USS(S) ________ ______________,

______ ________.

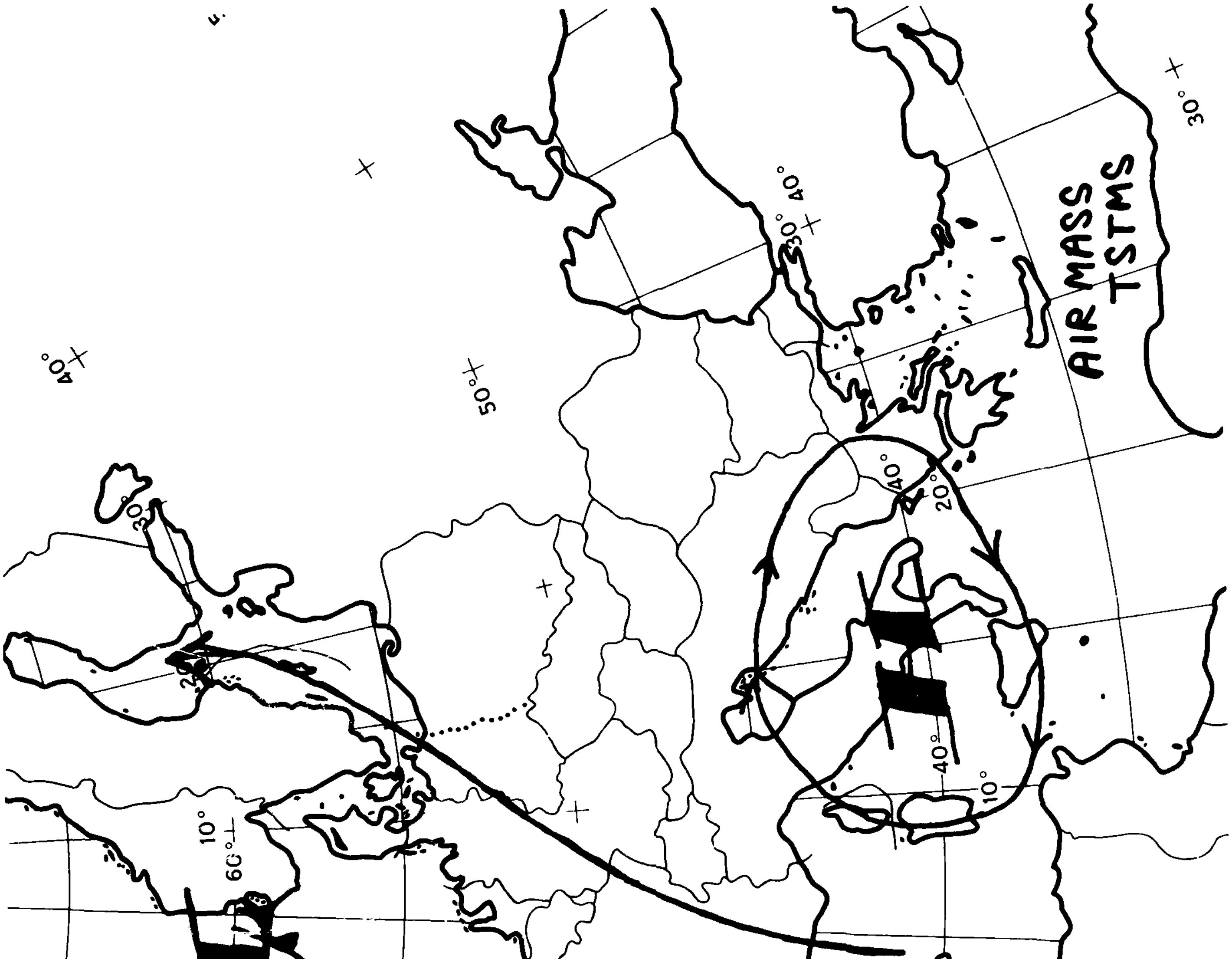
6. Showalters Index: 08221 ________, USS(S) ______ __________,

________ ________.

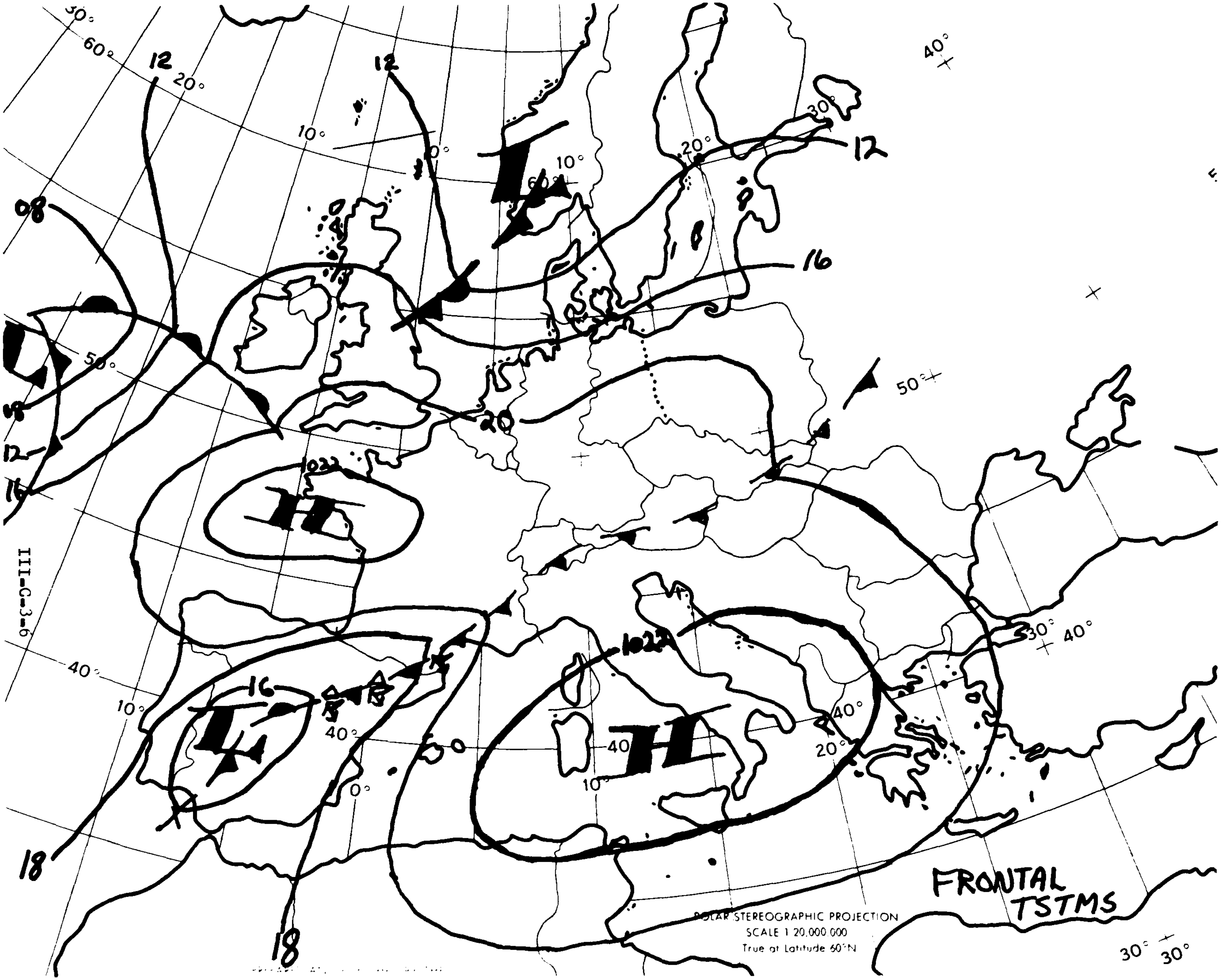
7. Trajectory Data: 850 ________ 700 ________ 500 _____________.

8. Summary of days Radar Obs:

Atch 1



Atch 2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III-C-3-6

AN INVESTIGATION INTO THE POSSIBLE USE

OF THE dBZ VALUES VS HEIGHTS IN IDENTIFYING AND FORECASTING

HAIL-PRODUCING THUNDERSTORMS AT ZARAGOZA AB, SPAIN

By: Captain Wayne M. Davis
Det 16, 31WS
1 February 1979

PURPOSE

The purpose of this investigation is to determine an objective radar method of identifying and forecasting hail-producing thunderstorms at Zaragoza AB, Spain by using the AN/FPS-77 Severe Storm Detection Radar.

RADAR INVESTIGATION RESULTS

The attached radar investigation was conducted Feb-Dec 79.

The results were very limited and inconclusive. Only twenty entries were made, 10 of which were outside 30NM radius of LEZG. Lack of data not withstanding, one observation can be made: Max Tops/Intensity do not necessarily indicate the presence or absence of hail. One afternoon in November we received a gust front which deposited pea-size or smaller hail and winds above 40 knots. Just a few minutes prior to receiving hail, we checked the radar and found only RW - with tops less than 20,000 ft.

The conclusion is that the technique used in the investigation cannot be applied to Zaragoza AB, primarily because of the mountainous terrain within 30NM of the base. It is felt that this technique would work quite well in certain locations where thunderstorms are common and the terrain is fairly flat such as "Tornado Alley" in the USA.

Although this investigation did not shed any light on improving our techniques, we still have some old indicators which all forecaster should know. These are enclosed in the Summary of Previous Studies/Investigation portion of this investigation and also the Local Severe Radar Criteria located in Book 1 of the Radar Files.

SUMMARY OF PREVIOUS STUDIES/INVESTIGATIONS

In 1958 and 1959, a Thunderstorm Study was accomplished at Zaragoza. The study determined that for an ideal thunderstorm situation, the following parameters should be present:

a. Southeasterly winds from surface to 5000 feet.

b. Southwesterly flow aloft that has been constant for 36 hours.

c. Showalter stability index of less than +4.

In April 1976, MSgt D. L. Fawver, Det 16 forecaster, compiled a list of Zaragoza Forecast Problems which contained a section on thunderstorms. The following information is relative to further thunderstorm investigation:

"The mountainous terrain around the Ebro Valley provides ideal thunderstorm development areas whenever airmass conditions exist so the problem is one of when the storms move over the base or form in the base area. Atch 1 reflects the ideal airmass thunderstorm situation in the Ebro area and Atch 2 the frontal thunderstorm situation. Wind gusts to 45 knots and hail up to 3 inches have occurred at Zaragoza AB with the frontal situation. In spring and summer, 35 knots of wind and pea size hail are common near sunset during April, May, July, August, and early September with the airmass situation. A combination of the two types occurs in late August and September as the receeding Azores high allows more and more fronts or troughs aloft to penetrate over the mountains of Northwest Spain, with an average of one per 18 hours passing Zaragoza in the zonal flow."

1. Introduction:

Forecasting thunderstorms at Zaragoza AB is complicated because of the local terrain. LEZG (Zaragoza Air Base) and the city of Zaragoza lie in the Ebro Valley with mountainous ranges on either side. Consequently, the thunderstorms tend to build up over the mountains and most of the time will remain over the mountains. Our problems begin when the thunderstorms enter the valley itself. Our Local Severe Radar Watch criteria places special emphasis on erratic movement of very strong or greater cells in the valley. This investigation will hopefully result in an objective method of identifying and forecasting hail-producing thunderstorms at LEZG.

2. Theory:

The basic theory was extracted from an article entitled An Observed Relationship between the Height of the 45 dBZ Contours in Storm Profiles and Surface Hail Reports by G. K. Mather and D. Treddenick. The article appeared in Volume 15 of the Journal Of Applied Meteorology. The basic concept is that hail is seldom produced unless the height of the 45 dBZ contour level exceeds 7.5 km (about 25,000 feet). In our investigation we will use this theory, expand on it if necessary, and include other parameters which may be useful in identifying and forecasting hail-producing thunderstorms.

3. Procedures:

a. During the period 1 Feb 79 to 31 Dec 79, the following data will be compiled whenever a strong or greater thunderstorm echo moves into or developes within a 30 NM radius of LEZG.

(1) Location of thunderstorm (example: 140/13).

(2) Intensity/Max Top (example: ++/340).

(3) Movement (example: 270/10).

(4) Maximum dBZ: First, obtain the maximum dB from the AR scope, then go to the P_r-Z_e Nomogram on the Radar Console. At the intersection of the distance and dB, read the dBZ rating on the right hand side.

(5) Height of maximum dBZ: Set the ISO-ECHO to the dB intensity as listed in para (2) above. Use the RHI Scope to find the core of highest intensity, then record the height of this max core.

(6) -22^{o}C Height.

(7) Tropopause Height.

(8) 500 MB Height.

b. At the end of December 1979, the data will be compiled to study relationships and develop an objective set of rules, if possible. One year of data may not be sufficient to draw any conclusions; we may have to continue for another year. We may find that the 45 dBZ vs 7.5 km height does not work at all at Zaragoza, or we may have to adjust the values. At any rate, this investigation should make all forecasters aware of the different parameters which could be associated with hail-producing thunderstorm occurrence of forecast.

SECTION IV

WEATHER CONTROLS

(The Seasonal Weather Controls were compiled for Zaragoza Air Base; however, due to their general nature, they apply to the Bardenas Reales Gunnery Range complex. The Zaragoza Air Base Seasonal Weather briefs were published by 21st Weather Squadron, date unknown.)

ZARAGOZA WEATHER SUMMARY

Zaragoza AB, Spain, is located at 41° 40' north latitude and 01°02' west longitude with a field elevation of 844 feet above mean sea level. It is situated in the Ebro River Valley, the longest valley in Spain. The valley is oriented NW-SE from the Mediterranean Sea to 40 miles south of Bilbao on the Bay of Biscay. A ridge with a maximum height of 5100 feet separates the Bay of Biscay from the head of the Ebro Valley. To the north of the valley are the Pyrenees Mountains rising to the height of 11,165 feet, forming a barrier between Spain and France. The southern boundary of the Ebro Valley is formed by two mountain ranges. To the west of Zaragoza is the Sierra de Moncayo Range with a maximum elevation of 7812 feet, located 35 miles due west of Zaragoza. To the south of Zaragoza is the Sierra de los Monegras Range, extending to the Mediterranean Sea. Extending southwest is a break between the two ranges, connecting to the head of the Tagus River Valley at Madrid.

There is no large body of water in the immediate area, except for the Ebro River. The Pyrenees Mountains, to the North, block most of the weather associated with fronts, lows and highs, located over the rest of Europe.

The greatest threat to Zaragoza, in the form of continuous precipitation and associated cloud cover, occurs when a low pressure system forms or passes through South-Central Spain. This is generally a fall and winter situation.

The majority of thunderstorms occur from May to September and are associated with a Southwesterly flow aloft. This flow is usually accompanied by sufficient moisture, and in conjunction with good surface heating and/or lifting, produces thunderstorms in the area.

Strong Northwest winds are caused by a pressure difference from the head of the valley to the mouth of the valley. The winds flow from the area of the highest pressure to the area of the lowest pressure. Due to the topographical effect of the valley, the wind is stronger with the high pressure area to the Northwest (Northwest wind) than with the high pressure area to the Southeast (Southeast wind) in the reverse.

Low visibilities caused by ground fog, haze, and smog, are the result of three main factors: terrain, circulation, and pollution source. This latter factor is caused by the industrial city of Zaragoza, 12 miles E-NE of the base. Smog is further intensified by contributions of smoke from a rubber factory and a railroad yard on the near side of the city. Concerning the circulation factor, there must be an Easterly component to the surface winds. Naturally, any flow directly from the city (E-NE) is the fastest and most effective; however, with radiational cooling forming a good inversion, the smoke eventually fills the entire valley, after which time the direction of the surface wind is no longer important. To these nuclei is added moisture from the Ebro River (5 mi.N) and a large canal running E-W just North of the base, irrigating the valley. With temperatures above 50 degrees, the result is usually smoke and haze with visibility 3-6 miles, depending upon temp.-dew point spread. With temperatures of 33 degrees to 50 degrees the fog is much more persistent. Due to the time necessary for the pollution to reach the base from the city, the lowest visibilities can be expected between 0900L - 1000L. The visibility will slowly increase with heating, or with wind shift to the South thru Northwest.

ZARAGOZA AB SEASONAL CLIMATOLOGY

SPRING (MARCH-MAY)

GENERAL: The spring season at Zaragoza is a period of excellent flying weather, strong surface winds and increasing thunderstorm activity. The upper-level winds begin to decrease, but orographic effects, such as clouds and turbulence, are still a dominant feature of the local flying area.

CLOUDINESS AND VISIBILITY: Spring brings the transition of the synoptic situation from the winter pattern of strong frontal systems moving through Iberia into the Mediterranean to the summer pattern of a super-imposed thermal low, a small surface pressure gradient. A few strong weather systems influence Zaragoza during this period but the flying conditions remain good. VFR conditions (1500ft/4.3NM) exist 94.3% of the time and conditions below 500ft/1NM minimums occur only 0.5% of the time. Indicative of the excellent conditions is the fact that more than one-half of the time during April and May there is no ceiling at all and visibility is unrestricted. March experiences these conditions 41% of the month.

PRECIPITATION: Zaragoza is a semi-arid region with a yearly rainfall average of only 15.5 inches. The spring rainfall averages 1.3 inches per month with extremes of 0.01 to 5.17 inches having been recorded. The rainfall is divided between steady rain occurring with frontal systems and showers which develop over the mountains. Rain or drizzle occurs on an average of 11.8 days per month. Thunderstorm activity at Zaragoza AB increases from less than one thunderstorm day in March to four days in May. Snow has occurred as late as March.

SURFACE WINDS: The primary controlling factor of the surface winds at Zaragoza is the Ebro River Valley. Of the annual winds, a total of 48.5% is from the west through northwest and spring contributes heavily to this average. March through May average 52.0 percent down-valley winds from the west through northwest and 19.2 percent up-valley winds from the east through southeast. The wind speeds are moderate to strong, with an average of 41.8 percent being over 19 knots. Maximum winds of over 40 knots have been recorded during all three months.

TEMPERATURE: The spring season sees a warming trend occurring throughout the period. The daily average minimum climbs from the low 40s in March to the low 50s in May, while the average maximum goes from the high 50s to the middle 70s. The absolute low ranges from 23°F in March to 39°F in May, while the absolute high climbs from 78°F to 93°F

LOCAL AREA WEATHER: The weather occurring within 100NM of Zaragoza AB varies considerably from the air base itself. The primary cause is the topography of the surrounding area.

Orographic upslope flow produces considerable cloudiness over the higher mountains. Favorable conditions for orographic clouds exist at least 50% of the time during the spring. Thunderstorm development over the mountains is approximately double that of Zaragoza AB during the spring.

The area is one of the most favorable ones for mountain wave development in Europe. Upper air winds are favorable for development (perpendicular to the mountain range orientation) approximately 5 of the time during the spring. In additions, winds of over 30 knots at 5000 feet MSL occur 13 of the time. These winds are predominately parallel to the major ranges but can produce cap-cloud formations and moderate low level turbulence in the vicinity of the higher mountains.

SUMMER (June-August)

GENERAL: The summer season at Zaragoza is a period of [illegible] with excellent flying weather. The upper-level wind speeds [illegible] annual minimum. Thermal and orographic effects are the dominant weather features throughout the area.

CLOUDINESS AND VISIBILITY: Summer is a season of small [illegible] over the Iberian Peninsula. The Azores anticyclone reaches its maximum [illegible]ward position, extending into the Bay of Biscay. Comparatively [illegible] low pressure system exist over northern Africa and the Mediterranean. [illegible]imposed on this general pattern is a thermal low over the central portion [illegible] Iberia. Clouds are usually limited to the area near the occasional weak [illegible] which enter the area. VFR conditions (1500ft/4.3NM) exist 98.2 of the time. Conditions below 500ft/1NM occur less than 0.[illegible], all cases being heavy showers of short duration. An average of 65.7% of the time there is no ceiling or restriction to visibility. The average total sky cover is less than three-[illegible] coverage.

PRECIPITATION: The Summer season is extremely dry, averaging less than 1.[illegible] inches per month, with June the wettest at 1.4 inches and July the driest at less than 0.5 inches. The rainfall is almost all from shower activity and wide variations occur. The highest monthly rainfall ever recorded at Zaragoza occurred in August, 5.20 inches. July has one of the lowest precipitation records - no precipitation at all was measured one year. Precipitation is recorded on an average of 7.9 days per month. Thunderstorm activity at Zaragoza AB occurs [illegible] days per month.

SURFACE WINDS: June through August averages 50.5 down-valley winds [illegible] 20.0% up-valley winds (E-SE). The speeds decrease slightly from the [illegible] recorded in the Spring but still remain moderate to strong.

TEMPERATURE: Summer temperatures are warm at Zaragoza, with the average [illegible] highs running in the low to middle 80s. The evenings are normally [illegible] the lows dropping into the high 50s to low 60s. July and August have seen [illegible] over 100°F and the record of 109°F was set in July 1978. Minimums have been recorded of 44°F in June and 45°F in August.

LOCAL AREA WEATHER: The dominant weather feature of the area within 100NM of Zaragoza is the high thunderstorm occurrence. The area has the highest [illegible] of days with thunderstorms on the Iberian Peninsula. The "Calendario Meteoro Fenologico" issued by the Spanish Meteorological Service indicates an average of

over 20 thunderstorm days per month from June through August. The maximum occurs in the Huesca province, just north of Zaragoza. The thunderstorm activity is triggered by a combination of thermal and orographic effects. The activity normally begins in the early afternoon, reaches a peak about one hour before sunset and dies off about three hours after sunset. The first cells will form over the mountains and then move out over the valley.

The upper air flow diminishes in the summer to its minimum annual velocity. The main European jet moves northward and weakens, decreasing the probability of mountain wave development to near zero. The moderate low-level mechanical turbulence of the winter and spring gives way to afternoon light chop produced by differential heating.

FALL (September-November)

GENERAL: Fall is a season of deteriorating flying weather. Thunderstorm activity decreases rapidly after a peak in September. The upper-level winds increase in velocity, and orographic effects, such as clouds and turbulence, becomes a major feature of the local flying area weather.

CLOUDINESS AND VISIBILITY: Fall is a transition period from summer's thermal low and relatively flat pressure gradient to the more active winter pattern. The Azores anticyclone moves southward to its wintertime position, giving excellent weather in September as it dominates Iberia. October and November see increasing frequency of depressions and frontal activity, bringing increased cloudiness and visibility restrictions. VFR conditions (1500 ft/4.3NM) exist 84.9% of the time, decreasing from 91.8% in Sep to 80.9% in Nov. Ceiling and/or visibility conditions below 500ft/1NM occur 3.2% of the time increasing from 0.6% in Sep to 5.8% in Nov. Conditions of no ceiling and unrestricted visibility decrease from the summer high of over 65% to an average of 39.4% in the fall. The average total sky coverage increases from less than three-eighths in summer to more than four-eighths in fall.

PRECIPITATION: Fall is the rainy season with an average monthly rainfall of [illegible] inches, more or less evenly divided over the period. The minimum rainfall that has been recorded in any one month is a trace in September, while the maximum [illegible] October. Precipitation occurs [illegible] Thunderstorm activity [illegible] days and then rapidly decreases to less than [illegible] occurs at higher elevations during late fall, it usually [illegible] December at Zaragoza AB.

SURFACE WINDS: The fall season bears out the prevailing direction [illegible] but shows more variance than the other seasons. The effect of the shifting Azores anticyclone tends to damper the speed and increase the variance in direction. The fall season has an average of 42.8% down-valley (W-NW) winds and 22.9% up-valley (E-SE) winds, well below the average. The speed also drops in fall, showing an average of only 33.7% above 10 knots compared with 41.8% in spring. Although the percentage above 10 knots drops, the absolute maximums increase. A record speed of 73 knots occurred in November 1979 and winds over 55 knots have occurred in all three months.

TEMPERATURE: The temperatures in fall are quite variable. Periods of Indian Summer are mixed with cold, windy periods, but in general cooling occurs throughout the season. The average daily maximum drops from the high 70s in September to the middle 50s in November and the daily minimum goes from the high 50s to the low 40s. The absolute maximum in September is 96°F, while it is only 75°F in November. The absolute minimum drops from 41°F in September to 26°F in November.

LOCAL AREA WEATHER: This area has the highest thunderstorm activity concentration in Iberia. Although the base averages only five thunderstorm days in September, Spanish data for the period 1964-1969 indicates an average of over 15 days for the 100NM area around Zaragoza. As many as 25 thunderstorm days have occurred in one month. The activity drops to an average of less than three thunderstorm days a month by November.

The upper-level flow increases from its summer minimum speed toward the winter maximum, becoming stronger and more westerly during the fall. The prevailing direction is SW-W as compared to the winter direction of (W-NW). The percentage of winds above 30 knots at 5000 feet jumps from less than 3% in summer to over 15% in fall. The combination of the strong winds and SW-W flow produces perfect conditions for mountain wave activity in the vicinity of the surrounding mountains. Cap-clouds on the mountain tops and areas of light to moderate turbulence becomes an almost daily occurrence. Severe mountain wave turbulence is possible during this period.

WINTER (December-February)

GENERAL: The winter season has the worst flying weather of the year at Zaragoza AB, but still the base is at one of the best weather locations in Europe. The surface and upper-level winds are the strongest of the year. They produce orographic clouds and turbulence over the entire local area.

CLOUDINESS AND VISIBILITY: The Azores anticyclone reaches its most southern position and many low pressure systems are formed in the Mediterranean Sea. Depressions and frontal systems effect Zaragoza throughout the period, often recurring on a 36 to a 72 hour cycle. The worst conditions occur with a strong depression moving across southern Iberia or through the Strait of Gibraltar into the Mediterranean. This synoptic pattern produces strong up-valley flow from the southeast with extensive low clouds and precipitation. This pattern will sometimes produce snow at Zaragoza. VFR conditions (1500 ft/4.3NM) exist 73.8% of the time and conditions below 500ft/1NM average 10.2%. The average total sky coverage reaches the yearly high of five-eights coverage and observations of no ceiling or visibility restrictions are recorded only 33.7% of the time.

PRECIPITATION: The winter rainfall averages 1.1 inches per month. The range of monthly extremes is from a minimum of a trace to a maximum of 3.65 inches. Snow has occurred all three months but averages less than an inch in any one month. The maximum amount that has been measured for any 24 hour period is less than five inches. Snow is only observed, on average, every other winter season. Thunderstorms are occasionally recorded but they average less than one occurrence day per month.

SURFACE WINDS: The primary direction-controlling factor of the surface winds at Zaragoza is the Ebro River valley. A total of 48.5% of the year-round winds are from the west through northwest. The winter is slightly below this average with 45.8% down-valley (W-NW) and 19.6% up-valley (E-SE). The percentage of winds with speeds over 10 knots is the lowest of the year at 32.4%, but the maximum wind speeds are the highest with a record of 56 knots in January. Both December and February have had winds over 45 knots and during almost all winter months 40 knot gusts are recorded.

TEMPERATURE: The temperature range at Zaragoza is not large during the winter. Daily minimum temperatures below freezing occur less than one-half of the days. The normal minimum is in the middle to high 30s, but records of 16°F have been recorded. The daily high usually is in the upper 40s or low 50s. Record highs range form 71°F in December to 73°F in February, although February shares the record for the coldest month too.

LOCAL AREA WEATHER: The surrounding terrain produces weather within 100NM of Zaragoza which often varies considerably from that at the air base. The low and middle cloud layer, which do not seriously effect the air base, become dominant features in the mountain area. The moist flow over the mountain ranges produces orographic clouds, obscuring the mountain tops for days and sometimes weeks at a time. Between 20% and 30% of the days have conditions which would hinder low-level VFR flights in the area.

The upper-level wind speeds increase to their maximum during the period, but swing more into the northwest. The shift in direction to become more parallel with the major mountain ranges offsets the increase in speed, thus low-level orographic turbulence does not increase significantly from the fall season. There are nearby areas of possible light to moderate low-level turbulence almost daily. The Zaragoza area is one of the most favorable in Europe for mountain wave development since more than 15% of the time winds are perpendicular to the nearby mountain ranges. Areas of severe turbulence can be found in the vicinity of the mountain waves.

WEATHER CONTROLS/FORECAST PROBLEMS/AIDS AT ZARAGOZA AB AND IN THE EBRO VALLEY

(As revised by MSgt D.L. Fawver, 22 Apr 76)

1. FORECAST PROBLEMS:

a. Visibility Restriction:

(1) Haze and Smoke: The Zaragoza AB RUSSWO (1957 - 72) reflects a 10% occurrence of haze and smoke at the base, increasing in winter to a January maximum and decreasing in summer to a July minimum. The major pollution and smoke sources in the vicinity of the base are the city of Zaragoza, 8 NM, ESE and the surrounding industrial complex. Under stable conditions, visibilities of 3.0 to 1.5 NM in haze and smoke are common in the colder months. After harvest of the surrounding farmlands and prior to planting, farmers burn stubs, stocks, and dry weeds in clearing the land. Under stable conditions, this is a significant smoke source.

(2) Dust: The Ebro Valley is lined with fertile farmland. The area surrounding the base and city of Zaragoza, as well as the entire Ebro Valley, provides large amounts of dust during clearing, plowing, and planting of farmlands. Dust is not a significant problem at Zaragoza AB, but does restrict visibilities to 4 or 5 NM preceding the first thunderstorm following dry periods.

(3) Fog: The Zaragoza AB RUSSWO (1957 - 72) indicates fog as primarily a winter problem with max occurrence of over 20% in December and January (494 of the 744 hours in January). With an average of 8 fog days in January (figure 1) fog is by far the most significant restriction to visibility. Due to the situation of the Ebro Valley in the horseshoe of the surrounding mountains (open to the Mediterranean Sea), the synoptic situation creating the inversion necessary to trap pollution in the valley is similar in all visibility restriction cases; a high pressure ridge east of Zaragoza, and/or a low to the west between 10W and Zaragoza. (Frontal systems under stable conditions are difficult, in the least, to find in the mountain areas). Under weak pressure gradients a bimodal visibility minimum occurs at Zaragoza due to the valley slope; one between 0600 and 0800L caused by radiational cooling at sunrise and the second between 1000 and 1300L as heating up the valley causes a windshift to the east and the pollution from the city is added to the fog situation. This second minimum takes a much longer time to improve since in addition to the increased condensation nuclei, easterly wind drift is slightly upslope at the base. The bimodal minimum will not be as noticable when the fog bank has built to above field elevation prior to sunrise. Generally the conditions causing fog are transitory and do not persist for more than 3 days, however, on an average of twice yearly the fog situation stagnates and persists for 5 to 10 days. Under this condition (figure 2), as the inversion intensifies and the high in the Mediterranean Sea blocks the only other escape of the pollution down valley, a type of high inversion fog builds throughout the Ebro Valley and persists until the situation changes to eliminate the inversion or permit drainage to the east.

When this stagnant condition occurs in the colder months the airfield will remain below flying minimums for 4 to 8 days, breaking only temporarily with diurnal heat or frequently not at all.

(4) Precipitation: Due to the upslope condition from the east, whenever any form of precipitation occurs with a surface wind direction from 040 to 120 degrees, the visibility will drop to between 0.5 NM and 2.5 NM as long as precipitation and that wind direction persists. This includes thunderstorms which move to the east of the base causing the wind to shift.

b. Strong Surface Winds: The Zaragoza AB RUSSWO (1957 - 72) indicates surface winds above 33 knots are predominately from WNW-N and mostly during spring (April and May) and late fall (November and December) but do occur any month except September and October. Other than hazardous flight and landing conditions, winds above 33 knots limit ramp maintenance of aircraft, rescue operations and cause dangerous low equivalent temperatures in exposed areas during colder months. Due to the orientation of the Ebro Valley the typical wind situation is created with a building high over England and the Bay of Biscay area and a low in the western Mediterranean Sea, (figure 3). The valley has a funneling effect on direction and, due to the narrowing in the valley around Moncayo and its ridges, a venturi effect on the speed. A 19 foot knoll in the runway to the NW of the wind mast of runway 31R causes lee effect errors of 5 knots and 10 - 20° to the west of the strongest wind indicated properly for the ramp area on 31L, (the unrecorded side).

c. Thunderstorms: The Zaragoza AB RUSSWO (1957 - 72) reflects an average of 26 thunderstorm days per year, generally occurring from May through September, but can and do occur anytime. The "Calendario Meteoro-Fenilogico", published by the Spanish Meterological Service gives an average of 126 thunderstorm days per year in the province of Zaragoza for the years 1956 - 1961. In contrast to the Zaragoza AB RUSSWO "EL CLIMA DE ZARAGOZA" published by the Spanish Meterological Service reflects an average of 11.3 thunderstorm days (1926 - 1955) occurring at the airport in Zaragoza, and 1.1 hail days. The mountainous terrain around the Ebro Valley provides ideal thunderstorm development areas whenever airmass conditions exist so the problem is one of when the storms move over the base or form in the base area. Figure 6 reflects the ideal airmass thunderstorm situation in the Ebro area and Figure 6a the frontal thunderstorm situation. Wind gusts to 45 knots and hail up to 3 inches have occurred at Zaragoza AB with the frontal situation. In spring and summer, 35 knots of wind and pea size hail are common near sunset during April, May, July, August, and early September with the airmass situation. A combination of the two types occurrs in late August and September as the receding Azores high allows more and more fronts or trofs aloft to penetrate over the mountains of NW Spain, with an average of one per 18 hours passing Zaragoza in the zonal flow.

2. FORECASTING AIDS: The following aids to forecasting at Zaragoza AB have been objectively and emperically derived as good tools, and in conjunction with sound meteorological principles are indispensible as forecasting aids.

a. Synoptic Situation Forecasting: By noting the position and orientation of pressure systems and frontal systems (synoptic situation) the forecaster can tell the general weather pattern in the Ebro Valley.

(1) Figure 3 is typical of strong northwest winds and partly cloudy to clear conditions with good visibilities.

(2) Figure 4 causes cloudy, hazy weather with southeasterly surface flow, poor visibilities, and occasional rain or rain showers with diurnal maximum heat and pressure falls.

(3) Figure 2 is typical of persistent fog and stratus in the Ebro Valley. (Weak pressure gradients)

(4) Figure 5 causes persistent haze conditions, with easterly winds.

(5) Figure 6 is typical of airmass thunderstorms, while Figure 6a is that of frontal storms.

(6) Figure 7 causes continuous rain and light southeasterly winds and moist low level flow up the valley. (rain after fropa) Low must be 1008 mb or lower to cause wide spread rain all over the Ebro Valley.

(7) Figure 8 shows a typical snow situation associated with an artic outbreak from around the European extension of the Siberian high.

(8) Figure 9 is the continuation of 7 above and reflects a continued artic outbreak with showery type or occasional snow due to the downslope/lee trofing and continued cold air aloft over the western slopes of the mountains in western France.

(9) Figure 10 is typical of strong winter winds from the northwest. (Note the similarity to the snowshower situation, Figure 9). As long as the flow aloft continues anticyclonic, no significant cloud cover will occur. With the approach of an upper trof or front, surface wind will decrease and become more westerly. Visibilities will decrease only during showers with surface frontal/trof passage. This is ideal mountain wave conditions as upper trofs approach.

b. Upper Air Synoptic Forecasting: Frequently the upper air pattern will be more easily recognizable in typing or generallizing weather patterns in the Ebro. Here the upper flow is divided in three groups: (1) Zonal, (2) Transition, and (3) Meridial.

(1) Zonal Flow: Zonal flow aloft is caused by the east - west orientation of the axis of the Azores high and its position within 20°N and 40°N. This flow could reach 250 knots or greater at 300 mbs, depending on the season.

(a) In situation"W"(Figure 11) the displacement of a surface system or condition is rapid since the ridge between the two trofs normally has a transitory character. When this condition occurs near the 45° parallel and the laternal displacement is slow over the Bay of Biscay and the Pyrenees, it spawns rapid lowering ceilings and visibilities (stratus & fog) at Zaragoza AB. Before the warm front passes, moderate SE winds and a regime of fog and stratus persists; after the wind shifts to SW (240° 15g 20 knots, with showers in the vicinity), after the cold fropa,conditions improve greatly with very good visibilities. Precipitation is of short duration although intense. The low ceilings last about 12 hours and the fair skys associated with high centers near 36 hours.

(b) Another situation is the "M" (figure 12) which could be the "W" displaced further but is resolved to indicate a transitory low between two ridges of different origins; one warm (maritime) acting as the motor pushing the depression, and the other cold (continental) which acts like a brake, blocking the advance of the migrating low. In the Ebro, this situation could result in abundant and intense rains, especially if the cold high and dry central of France detains the cloud system and the warm frontal occlusion stays trapped between the double ridges of the Pyrenees and Iberica mountains, alligned with the Ebro Valley. These situations are very noticable in the lower plains (sfc to 700 mb) but tend to disappear in higher analysis, and resemble the classic indented wheel between the Azores high and the trofs of the Icelandic low.

(2) Transition Flow: The change from Zonal flow from the paralells to the meridians (N-S).

(a) Circulation "Z" (figure 13) divides Spain with a double curve: cyclonic in the Baleric Island area and anti-cyclonic-over the Bay of Biscay area. This is the situation which causes high winds from the northwest in the Ebro River Valley owing to lee trofing, and generally causes clear to partly cloudy skys and excellent visibilities.

(b) Situation "S" (figure 14) is the opposite of "Z", a high over France and the Mediterranean and low over the Gulf of Cadiz. The position of the high greatly effects Zaragoza weather: if centered over France and the isobaric curvature is anti-cyclonic in the area of the Ebro, extensive fog banks form in the winter months.

If the center of the low appears over the Straits of Gibraltar and tracks or situates itself west of a line from Almeria to Zaragoza, very humid southeast flow associated with general Mediterranean type rain over Iberia, including the Ebro Valley occurs. These situations (2 and 3) are clearly evident in the upper air analysis. The 300 mb charts are very representative and often times the jet streams bordering the centers form the assigned letters. Situation "3" is associated with a cold air mass over the land mass of France corresponding with the high aloft, while situation "2" implicates the formation of a pocket of cold air aloft over the Baleares.

(3) Meridial Flow: Circulation in the sense of the Geographic Meridians (north and south) cellular circulation.

(a) Circulation "Ω" (omeaga) (figure 15) is a dorsal high ridge orientated N - S over the British Isles between two lows, one over the Azores and the other, over the Baleares and the western Mediterranean. This situation is characteristic of very gusty northwesterly winds in the Ebro Valley, (cierzo) which blows uninterrupted during a period of three to five days. The jet streams at 300 mbs marks ver well this situation: the lowering jet stream brings very cold polar air associated with active cold fronts that penetrate into the high Ebro and pass the mouth of the river in 6 or 8 hours. The clouds pass very rapidly pushed by the NW winds, and the second day clear skys and excellent visibilities continue in the cold wind over the valley.

(b) The "V" circulation (figure 16) comes associated with a series of low level spoke trofs. If the high over Europe is reenforced, it acts as a blocking high making a marked southerly component in the jet streams. This flow brings to the Ebro, warm subtropical humid air in autumn and winter, with intermittent rains. (In summer this air comes from the Sahara and is very warm and dry.) If there is no high to block the advance of the trofs of low pressures, they produce marked changes in cloud cover and wind for intervals of 6 hours of SW cyclonic flow and another 6 hours of NW anti-cyclonic flow. (Intense thunderstorms in summer.) In winter, short lived prefrontal fog announces the arrival of this circulation. Generally these circulations last from 3 to 5 days and show better correlation when the lows and highs have closed isobaric patterns.

c. Fronts: Zaragoza surface weather associated with fronts is greatly modified due to the orientation and slope of the Ebro Valley and surrounding terrain. Accordingly, frontal effects occurs at Zaragoza long before the actual front arrives. The following aids and physical factors must be kept in mind to properly forecast weather conditions, with the approach of fronts:

(1) All fronts passing from the W - N quadrants have post frontal drying in the low levels below 4000 feet due to down slope and therefore generally cause VFR flying conditions behind the front.

(2) Unless a cold front is orientated sufficiently E - W to cause low level winds to be between 230 and 360° (and drying) pre-frontal weather will be moist due to lee effect winds (SE) below 4000 feet, with patchy stratus, haze or fog until the front is near, then possible intermittent rainshowers or thunderstorms restricting visibilities to 1.5 to 3.0 NM, until fropa.

(3) After fropa less than 5/8 cloud cover below 3000 and 5/8 or more between 5000 and 10000 feet and good visibilities with possible light rain (not wetting the surface due to increased downslope winds) will give good verification until the isobaric pattern becomes anti-cyclonic. See figures 7, 10 and 3 (in that order). In summer the worst thunderstorms occur as the front passes in this situation. (Figures 6 and 6a).

(4) With warm advection and cyclonic flow prior to frontal passage, southwest surface winds (crosswinds) are predominent and frequently ≥ 20 knots, as long as wind flow in the lower 10,000 ft is 240 to 300°. Peak wind occurs as surface temps coincide with or exceed the ambient air mass temp. Large ($\frac{1}{4}$ NM diameter) dust devils can occur in the warm dry SW flow.

(5) Cold fronts, warm occulusions and warm fronts passing from the N to S cause the poorest flying conditions at Zaragoza. Since the wind flow in the lowest 10,000 ft is S thru E and up the valley moisture from the Mediterranean Sea is advected into the LEZG area and local upslope conditions augment the situation.

(a) Cold fronts and warm frontal occlusions are rain makers. This synoptic situation (figures 3 and 14) brings warm moist air up the valley and continuous rain until passage of the occlusion aloft towards the north. Pre-frontal and post frontal weather is similar to warm frontal weather in the U.S. plains area with temporary clearing with fropa and scattered cumuliform clouds building behind the fronts. Sequences of associated weather are:

1. Persistent fog and haze with visibility varing from .5 NM to 1.6 NM for AM mins and 1.6 NM to 5.0 NM for PM max until low: (a) receeds SW ward; (b) Begins moving towards the north western Mediterranean Sea after development or deeping to 1008 mb or lower; (c) moves through the Straits of Gibraltar along the North African coast or; (d) Moves through Spain with a central pressure of greater than 1008 mb.

a. With the NE flow of continental dry air, rapid improving flying conditions and a shift to the NW of surface winds.

b. Begins with widespread AC/AS cigs over Spain and light occasional precipitation spreading to the NE over higher terrain with low movement. The valley fills with mid and lower mositure and rain begins at LEZG as low approaches or passes to the west of LEZG, and occasional rain continues until the low: (1) passes to the south causing the wind shift to the NW (10 - 15 knots) at surface layer. The over run condition created with this situation causes light to moderate rain at Zaragoza until the low enters the Mediterranean Sea and passes aloft. Strong NW winds follow this situation; (2) Passes to the west and moves NE or N causes rapid clearing as it passes 42N and moderate cumulus development behind (frequently thunderstorms). Low visibilities usually return with passage of rain showers.

c. AC/AS ceilings give way to clearing and light to moderate NW winds as low goes by 01° west toward the east. Generally good flying weather persists, with scattered cumulus and AC causing mid layer ceilings during max heating periods until flow over the valley becomes anticyclonic in the lower layers.

d. This transitory (usually relatively stable) low causes low visibilities until passage to the north or east of LEZG and then usually developes in the western Mediterranean Sea causing high winds from the NW at LEZG and good flying weather.

d. Emperical Aids in Forecasting the Elements of Weather at Zaragoza AB.

(1) Strong Surface Winds (≥ 25 knots) figures 3 and 10.

(a) The pressure gradient between the north coast of Spain near the origin of the Ebro Valley (LEXJ) and the mouth of the Ebro (LEBL) at 0000Z is the best aid in forecasting winds. With 500 mb winds support (300 - 030° ≥ 25 knots) use P(LEXJ-LEBL) X 3 = mean speed + 10 for gust factor.

(b) Gust spread max = $4\Delta P$-$3\Delta P$ (LEXJ-LEBL).

(c) Keep in mind climo.

1. Wind > 33 seldom occurs in September and October.

2. Most frequently or best correlation to wind rule is April thru May, and November thru December. Other months rule is a good guide.

(d) Cross winds (240 - 280°) ≥ 20 knots with situation of figure 11 and 12 prior to trof passage during late afternoon and evening (1400 - 1700L). For SW flow at surface, winds aloft must be 230° to 300°; Any further south lee trofing shifts wind to SE below 040 (check LEBR low level winds). This SW flow is drying and usually with warm air advection.

(2) Fog and Haze: Since the main difference between fog and haze is moisture, here they are grouped togeather. Due to the location of Zaragoza AB in the Ebro Valley, once the required inversion is present or forecast, the visibility depends on temperature, moisture, availability of condensation nuclei and windrift less than 5 knots in the Ebro Valley. Windrift can be anticipated through micro-analysis of the pressures, diurnal variations and changes in pressure, temperatures and temp changes (ΔT) in the valley. Basically the types of fog which occur at Zaragoza are radiation, high inversion, post/pre-frontal and advection/radiation or combinations of these types.

(a) Radiation and/or radition-advection fog. The intensity or visibilities associated with radiation-advection fog depend on the 3 basic elements of; (1) inversion and strength; (2) temperature ($\leq 45^{\circ}$ to $\geq 25^{\circ}$); (3) moisture and (4) windrift. Several indices of an inversion and its strength can be noted through pressure analysis in the valley. The following aids will assist in extracting information from available parameters in the early morning.

1. Up valley gradient (LEXJ-LEBL) is negative and usually less than 4 mb and down the valley drainage ($\leq$ 4 knots) is occurring. NOTE: The land - sea breeze front from the "Med" frequently moves up the valley NW of LEZG with up valley gradient $\geq$ 3 mb. If this is the case, surface winds will be SE 3 to 5 knots, 2 to 4 hours prior to sunrise and due to the warm air advection near the surface, the strong inversion necessary for dense fog will not set up.

2. 850 mb heights slope up valley (ΔPLEBG-LECH is neg) and conditions in para 1. above exist, with the down the valley drainage.

3. LEZG surface temp vs La Muela temp/wx (call gasoline pumping station at La Muela to get temps/wx) indicates a strong inversion or thick fog to above La Muela.

4. Aircraft reports on extent and thickness of fog. Once fog conditions (moisture, light winds, weak generally up valley-gradient, stability) have been forecast to occur or exist, an analysis of pressures in the valley will often assist in determining how the visibility will go and how long fog will persist. Use LEXJ, LEBL, LEBG, LELO, LEPP, LEBR, LEVT, LECH, and LEBG pressures.

a. Highest pressure to NW between LELO and LEZG - worst condition of haze or fog occurs late morning after the diurnal wind shift (0900 - 1100L). The ridge seems to move to the east towards the "Med" with heating. Frequently the east side of the base will be fogged in and the west open until the ridge passes the runway complex. Clearing occurs after drainage/gradient advects the fog bank down valley around nocturnal pressure max period.

b. LEZG highest pressure - fog/haze at sunrise, early shift of wind to east, worse condition, and longer lasting than that in case a. above.

c. Highest pressure east of LEZG - worse condition at sunrise but still persistent due to early wind shift to east and added pullution.

d. Once a gradient down the valley of $\geq$ 4 mb exists (LEXJ-LEBL is possitive) advect the fog out of the valley using P LEXJ-LEBL X 3 = speed under stable conditions. Under unstable condition advect with the front or trof.

e. No persistent fog once an inactive cold front gets within 100 NM of LEZG.

(b) High Inversion/Advection fog. When the mouth of the Ebro Valley is closed to cool air drainage by a high pressure ridge in the western Mediterreanean Sea (up valley gradient), and a strong inversion exists, wide spread fog forms throughout the valley similar to high inversion type fog. Diurnal variations in heating cause the low level flow to advect the dense fog up and down the valley with apparrent in-exhaustible fog and condensation nuclei from cities and industry in the area. Under these conditions, visibility will remain below minimums throughout the day with upslope cooling and additional condensation nuclei abetting any improvement and augmenting the fog. This synoptic situation (a ridge in the Mediterranean and/or a low in the eastern atlantic) intensifies the inversion and the fog becomes thicker with possibilities of breaking the inversion with diurnal heat less and less each day. In this case the air field will remain below flying minimums from 1 to 5 days. The best conditions ($\approx$ 200/0.8 NM) occur twice daily, near max heating (1600L) and after down valley drainage has set up long enough to drain the fog down valley (nocturnal max pressure period). Once the valley gradient becomes possitive or down valley, slight improvement near the ground due to minor downslope warming occurs. Under these conditions a frontal passage or trof passage, bringing air cool enough to eliminate or break the inversion aloft, is necessary to alliveiate the fog situation and is seen as a major change in the synoptic situation. Once a down the valley gradient of $\geq$ 4 mb exists (4mb is required to eliminate a diurnal wind shift), the fog can be advected at the speed from wind rule P (LEXJ-LEBL) X 3.

(c) Post Storm/Frontal Fog. Due to the slight up slope condition from the east (100 ft X 30 NM) any precipitation occuring with winds of an easterly component becomes ideal fog condition, depending on stability. Thunder storms frequently pass through the base area, after which the cold downrush causes the wind shift and visibility to drop to .8 to 1.5 NM. Steady precip under relative stable conditions can cause best diurnal conditions to be 8000/1.5 NM.

(3) Thunderstorms: Forecasting thunderstorms at Zaragoza is one of the three major weather problems. During spring and fall, thunderstorms at Zaragoza will be more associated with frontal and trof passages, while during summer most are air mass or orographic.

(a) Air Mass Thunderstorms - Usually the second and subsequent days of southwest flow aloft (to above 500 mb) creates ideal airmass thunderstorm condition in and around the Ebro Valley in summer. (See figure 6). The primary formation areas for these cells are over the foothills and ridges, surrounding the valley. Once the cumulus temp has been reached the cells form and dissipate over the surrounding hills draining cool air into the valley and limiting the temperature in the valley to just below the cumulus temperature, (Tc ± 2°C as taken from the Barajas 08221 Raob and adjusted to LEZG surface temp/Td). Timing, severity, hail size and winds follow closely the predictable value as determined in AWSTR 105-200 using the Barajas 0000Z sounding adjusted to LEZG surface temp and dew point. Trajectory paths follow the terrain features as the cells take the paths of least resistance (the warmer air). Once radiational cooling begins and the hilltops cool these airmass thunderstorms will either dissapate (if no LFC exists in the raob) or build intensity (if LFC exists in raob) and begin moving over the valley (path of least resistance where warmer air still exists).

(b) Orographic thunderstorms. Only in an air mass where an LFC exists below 7000 ft will orographic thunderstorms occur at the base. In 20 cases, 1972 - 1975, where the Lfc was not below 7000 and a substancial positive area existed in the Raob, orographic cells of intense (XX) or very strong (PsPs) intensity were noted on the Zaragoza AB radar to form on the windward side of Moncayo and over the mountain ranges near Huesca and in all cases, once the cells moved from the initial upslope ridge, they either dissipated or deteriorated to strong (Ps) or less intense cells. These thunderstorms will seldom give anything more than pea size hail or winds near 35 knots since they are generally high based with high wet bulb zeros.

(c) Frontal or Squall Line thunderstorms. This type of thunderstorm is the hail producer at ZAB. Frequent 3/4 to 1 1/2 inch hail occurrs in the spring and late summer with trof passages and frontal passage thunderstorms. If any of the radar severe indices occur with this type, they merit watching. Winds preceding these storms can be anticipated from ΔP(LEXJ-LEBL) X 3 plus speed of storm. In one case (Sep 71) a storm seemed to stop over Zaragoza City, built back over the base and as it zagged back over the helicopter hanger and ramp, dumped hail stones and flat ice discs of 3 inch diameter on aircraft, hanger skylights, and cars along the flightline.

e. General Climo:

(1) In general, winter weather sees increased westerly flow over Europe interrupted by increases transitory or migratory systems both near the surface and aloft. These transitory systems, whether they are fronts, highs or lows, cause severe transition zones but, improving flying weather over most of the land portions of Europe while the prevailing westerlies bring low ceilings and limiting visibilities; whereas these same type systems cause restrictive flying weather over the water surfaces and in the westerlies above these areas. With the increasing moisture in the westerly to southwesterly (NW and W over Iberia) flow in the lower and mid levels, accompanied by lowering freeze levels, aircraft icing, turbulence, and alternate air field conditions become increasing hazards to flying throughout Europe and the western Mediterranean area.

(2) Iberian Climo: One of the most important areas of winter cyclogenisis affecting Iberia is just off the southwest coast of Spain and Portugal in association with the mean polar frontal position. (Figure 1a). This causes many of the frontal systems to occur over Spain and many fronts during winter pass from the W to SW. Considerable increases of fog stratus, thunderstorms and other frontal activity are in evidence over Spain, Portugal, and the North African coast, and in the western mediterranean sea, either associated with the polar front, increased frequency of artic outbreaks, or cyclogenisis over the area.

(3) Zaragoza (Ebro River Valley) weather: ETAC climo indicates fog and haze being the primary winter problem (ref climo charts) with winds running a close second. Even though precipitation takes the back seat in winter (Nov, Mar, and Jul being max months), it cannot be regarded as insignificant. Thunderstorms are the most significant summer phenomena.

Frontal Systems: Since virtually all of Spain is mountainous except the southwest, it is difficult, in the least, to locate frontal systems on surface synoptic charts both LASC's and the centrally produced products. The continuity established on the large scale products is helpful if carried even though dropped on centrally produced analysis and progs.

f. Summary:

(1) As winter approaches, the Bermuda high recedes southward with the sun; the Icelandic low intensifies; the Polar Front becomes more pronounced over the North Atlantic and the Mediterranean; and increasing cyclogenisis is evident over most of the North Atlantic.

(2) With increasing max winds cores. turbulence in the vicinity increases. Under these max wind cores. the mean positions of the polar and artic frontal areas show increased activity, as the mean ridge over the mid latitudes migrates southward with the winter sun, allowing mean surface winds to prevail westerly to the north of the polar jet and easterly to the north of the arctic jet. Noted increases in precip and fog in Nov, with the increasing polar and arctic outbreaks announce the arrivial of winter.

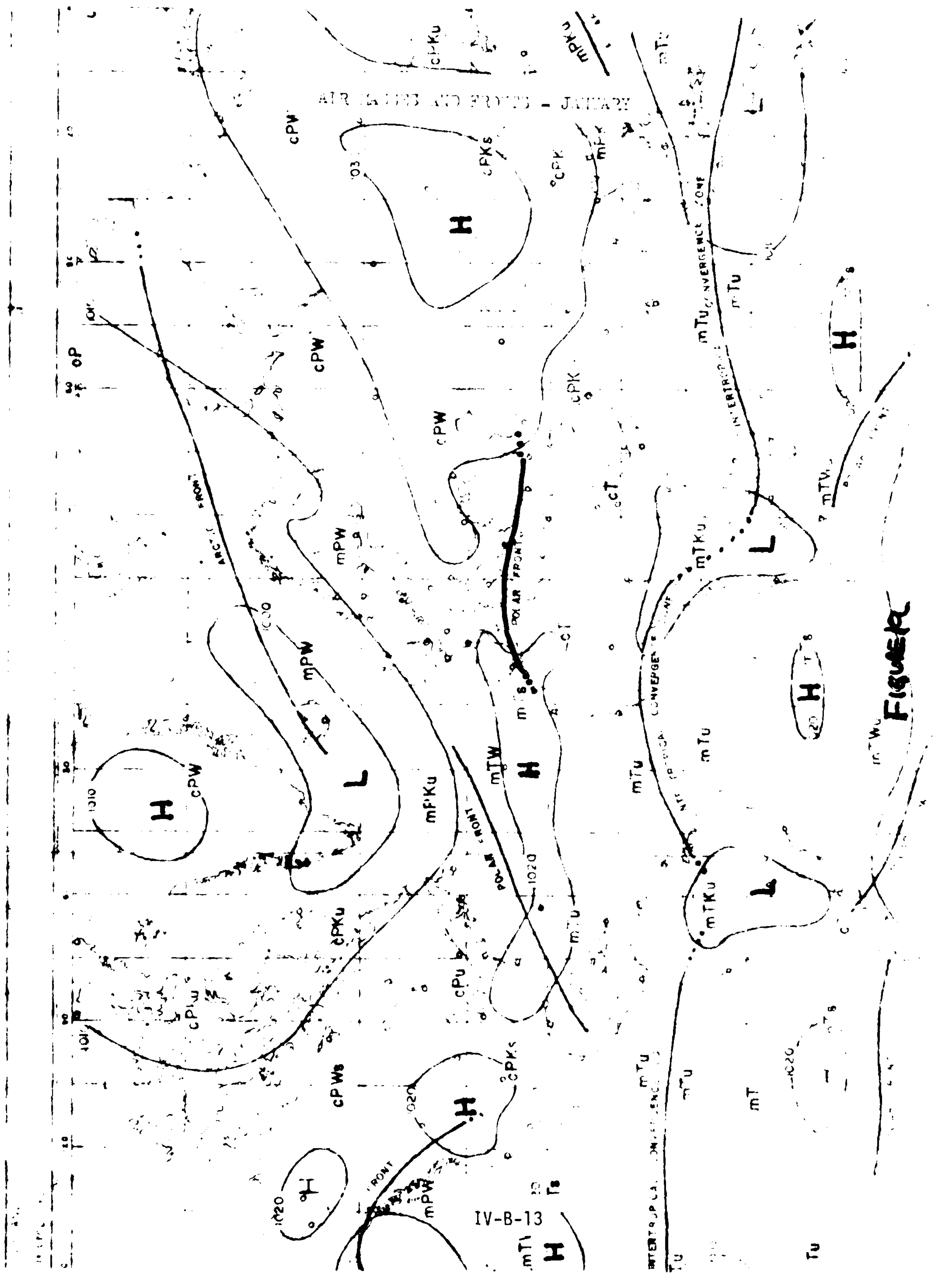
(3) Winter ends in a rapid decrease in low visibilities and increase of spring precipitation in March, april, and May in the Ebro river valley, as the transition period from winter to summer rapidly approaches, and recedes, followed northward by the sun's annual migration with the band of high pressures.

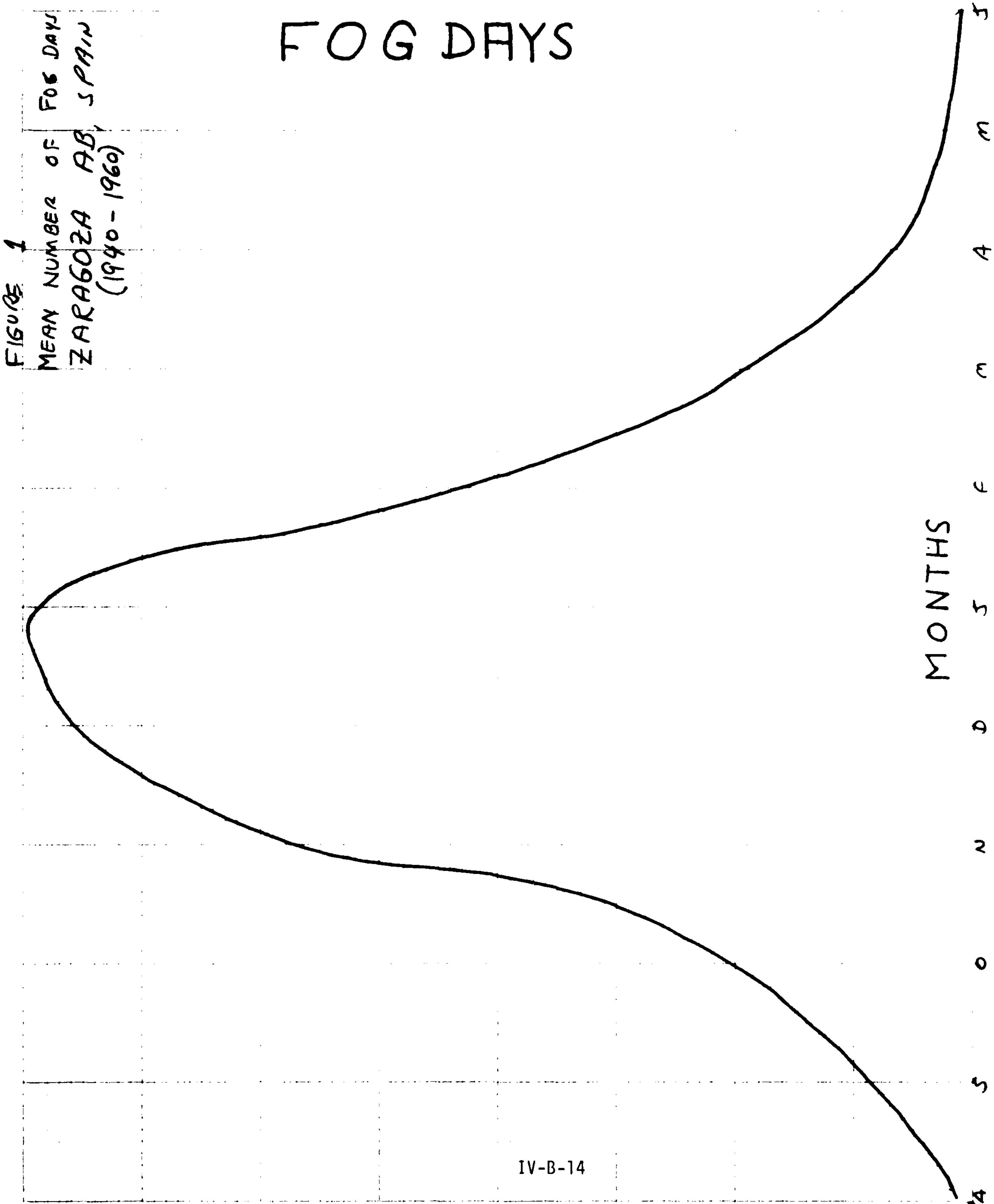
(4) During summer, increasing temperatures and instability in the low levels as the mid and hi level westerlies undulate from west to southwest decreases and increases low level moisture, bring alternate (warm) dry and moist low level flow and alternate periods of clear and thundershowers respectively to the Zaragoza and Ebro area.

(5) Summer is followed by the approach of the fall storm track on its way southward following the receding sun and the band of high pressures, completing the seasonal cycle.

ATTACHMENTS
Figure 1 and 1a
Figure 2
Figures 3, 3a, and 3b
Figure 4
Figure 5
Figure 6 and 6a
Figures 7, 7a, and 7b
Figures 8, 9, 10, 11, 12, 13, 14, 15 and 16

AIR MASSES AND FRONTS - JANUARY




FOG DAYS
FIGURE 1
MEAN NUMBER OF FOG DAYS
ZARAGOZA AB, SPAIN
(1940-1960)
MONTHS
0
1
2
3
4
5
6
7
8

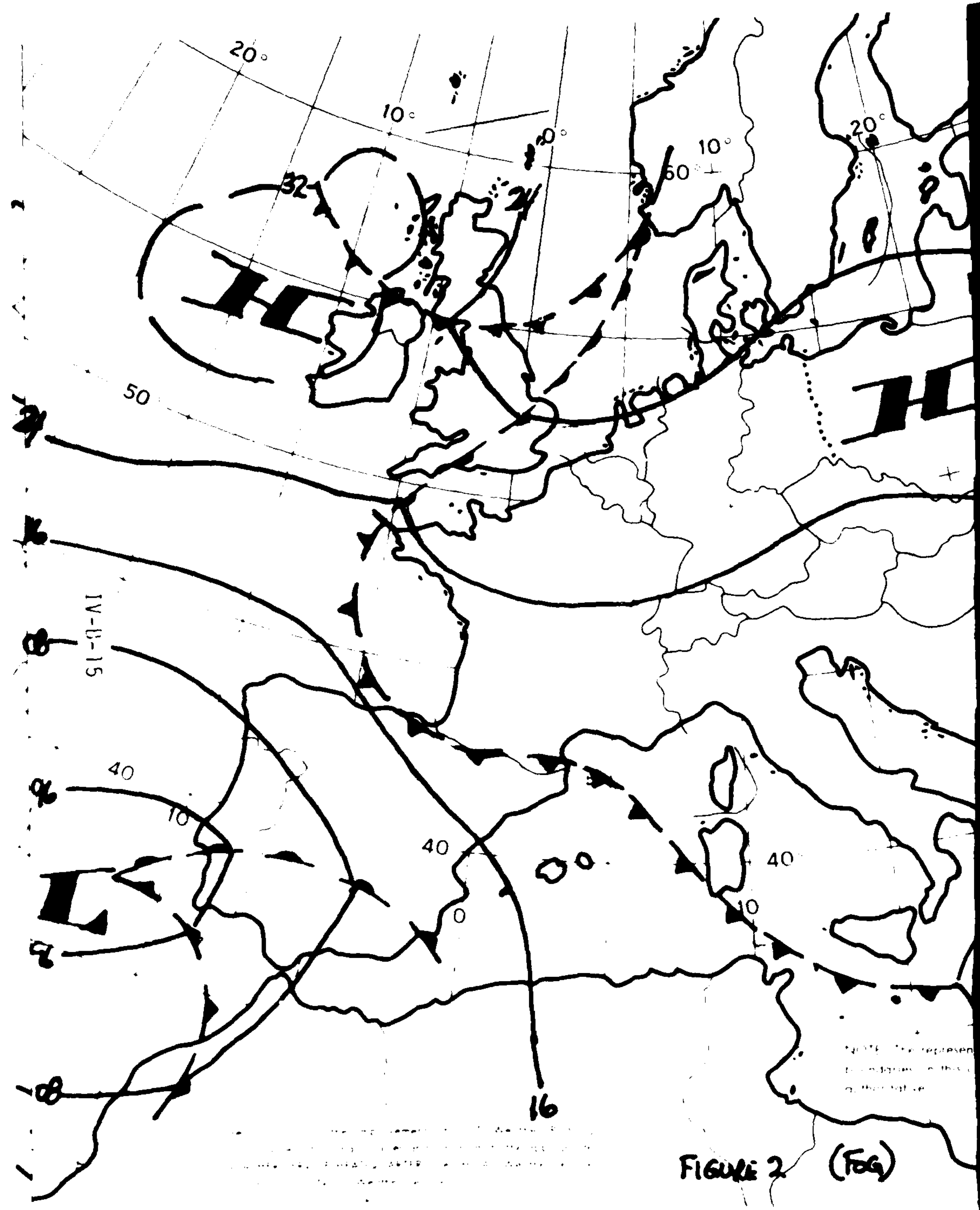


FIGURE 2 (FOG)

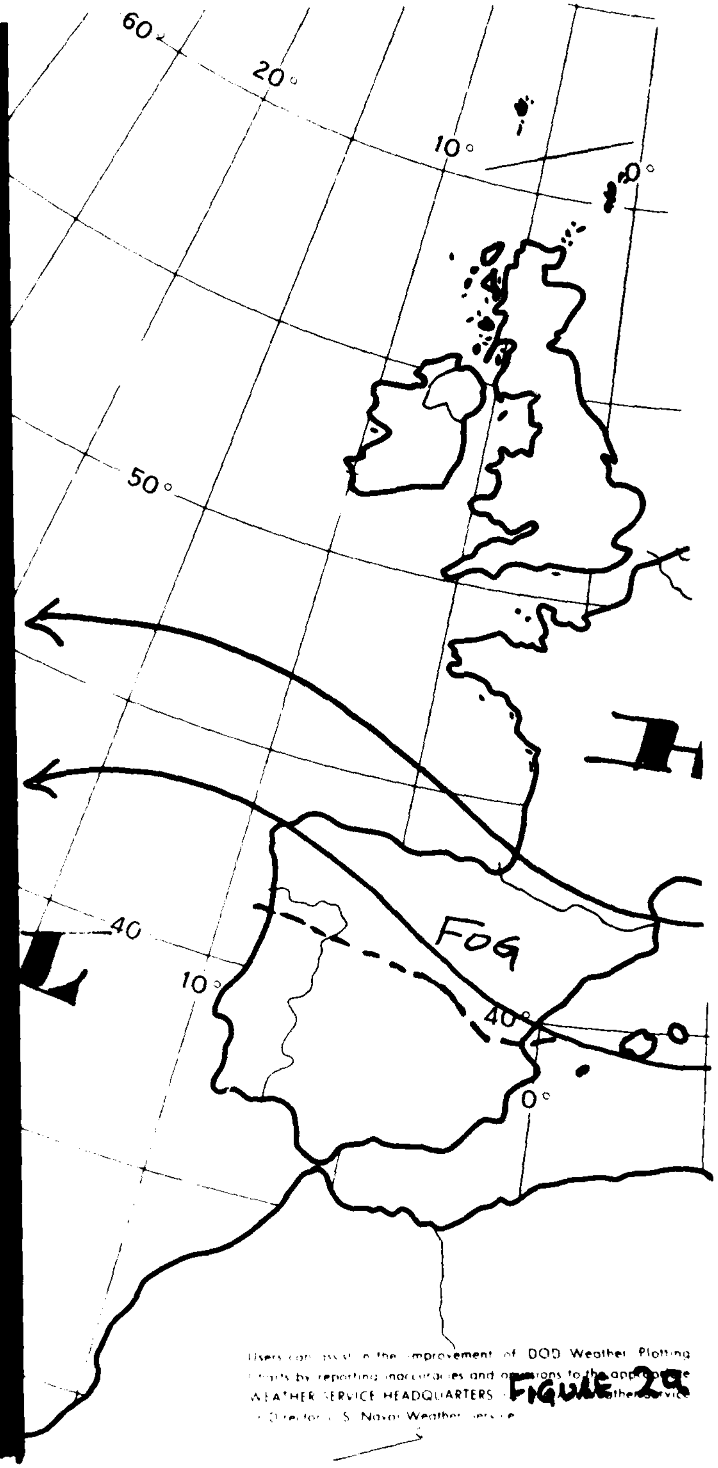


FIGURE 2a

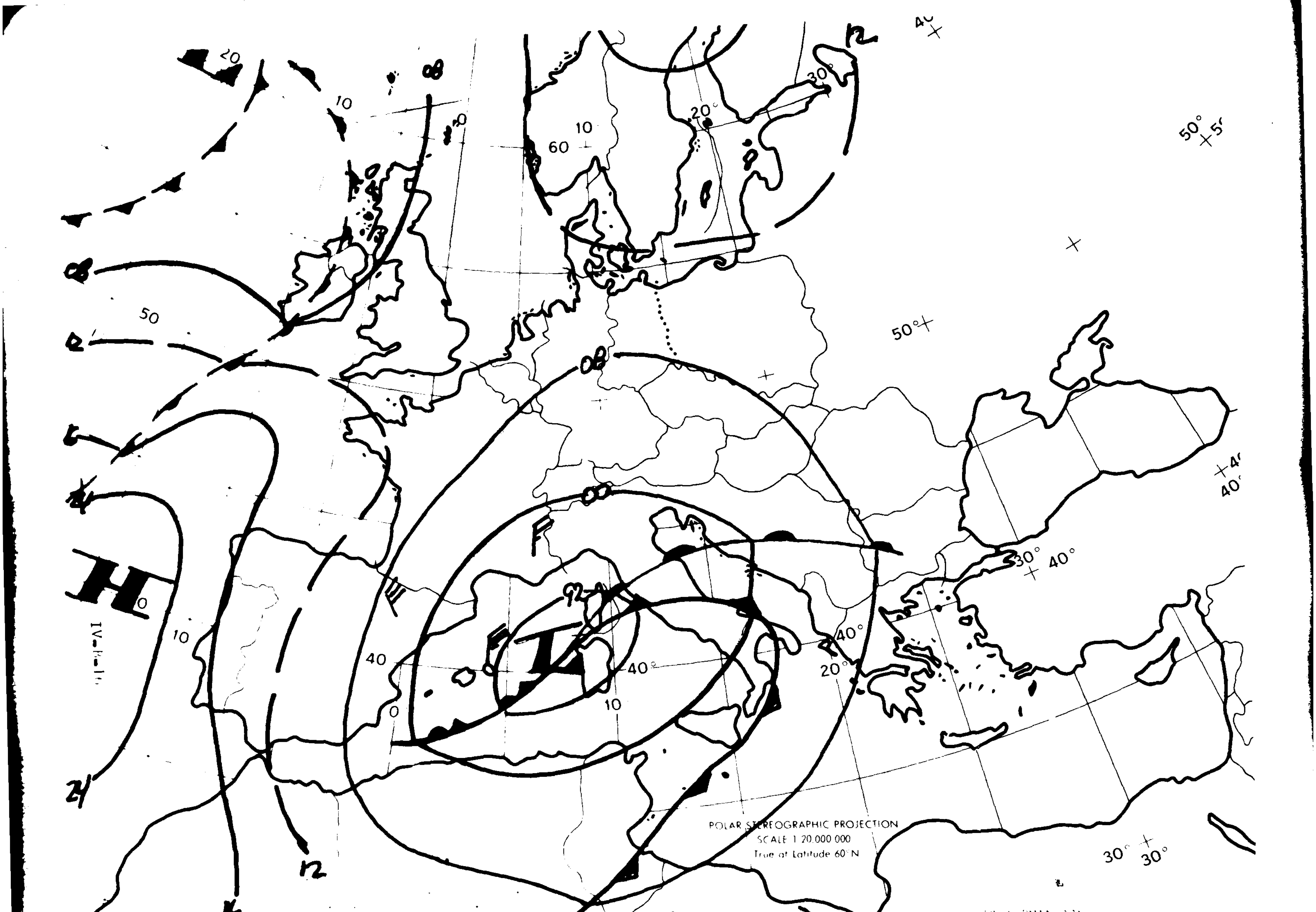


FIGURE 3 (STRONG WINDS)

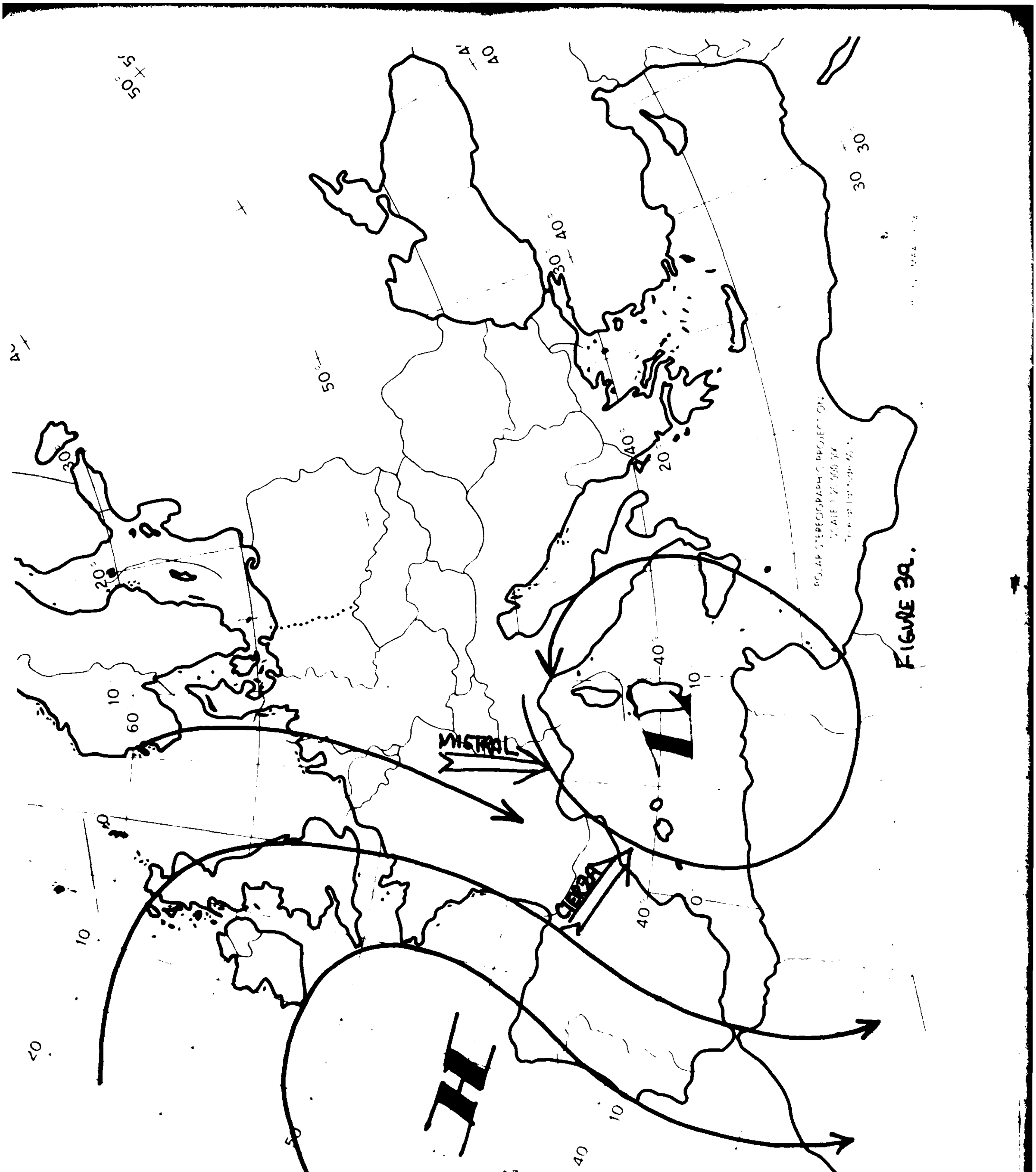


FIGURE 3a.

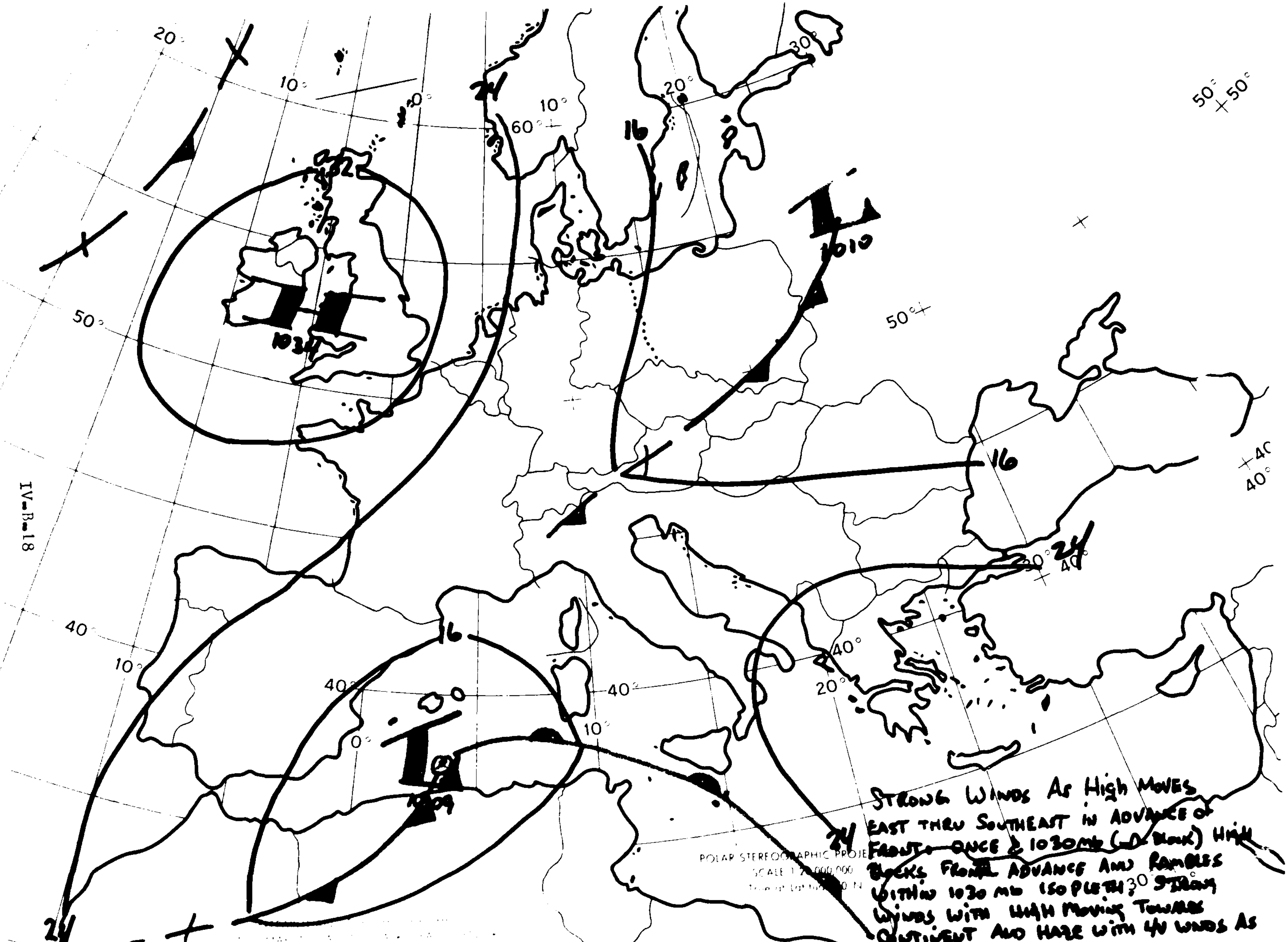

STRONG WINDS AS HIGH MOVES
EAST THRU SOUTHEAST IN ADVANCE OF
FRONT. ONCE 1030MB (-D- BLOCK) HIGH
BLOCKS FRONTAL ADVANCE AND RAMBLES
WITHIN 1030 MB ISOPLETH, STRONG
WINDS WITH HIGH MOVING TOWARDS
CONTINENT AND HAZE WITH LIGHT WINDS AS
HIGH RECEDES (AXIS).
POLAR STEREOGRAPHIC PROJE
SCALE 1:20,000,000
1034
1009
1010
16
24

FIGURE 3b

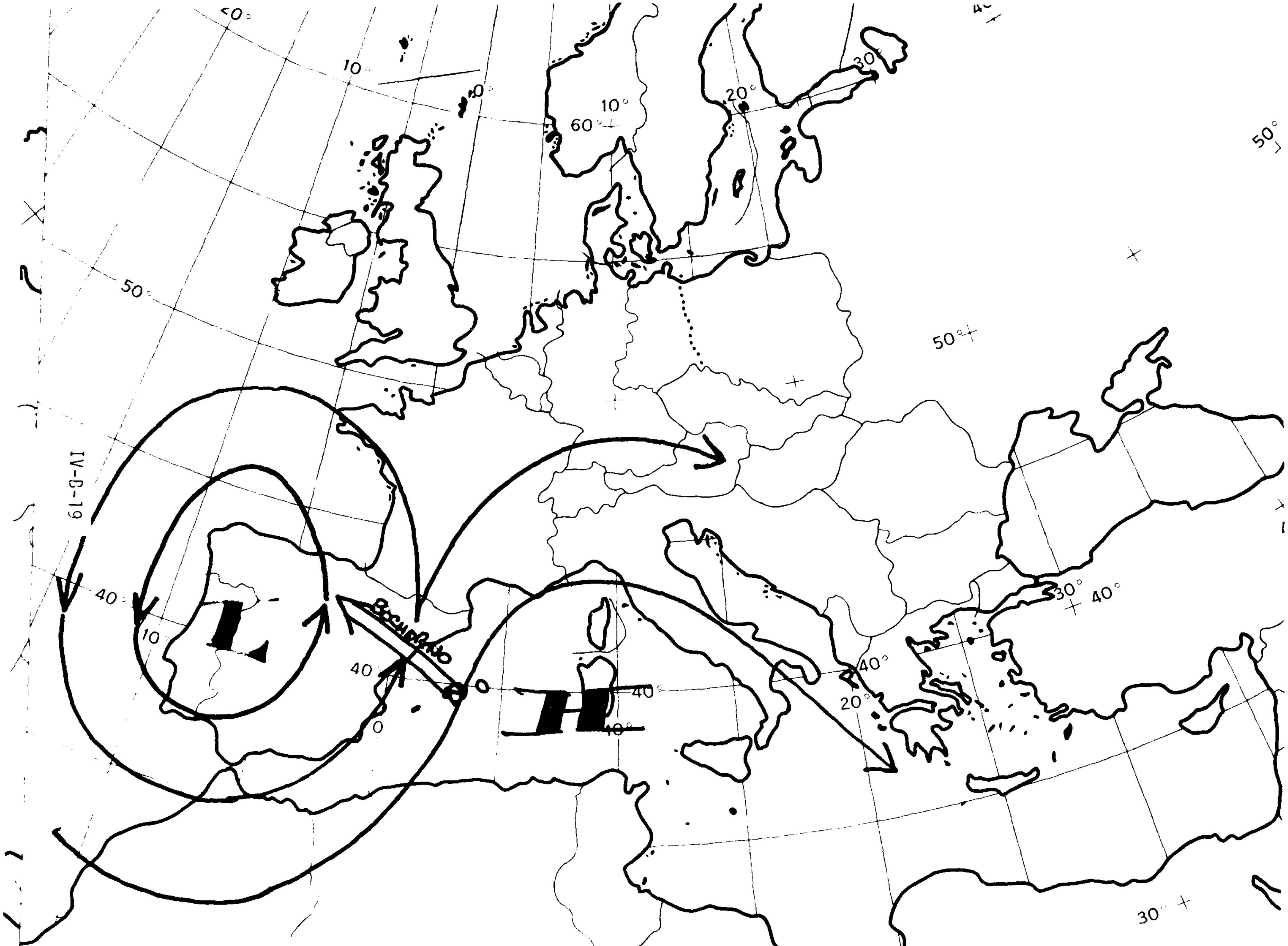


FIGURE 4

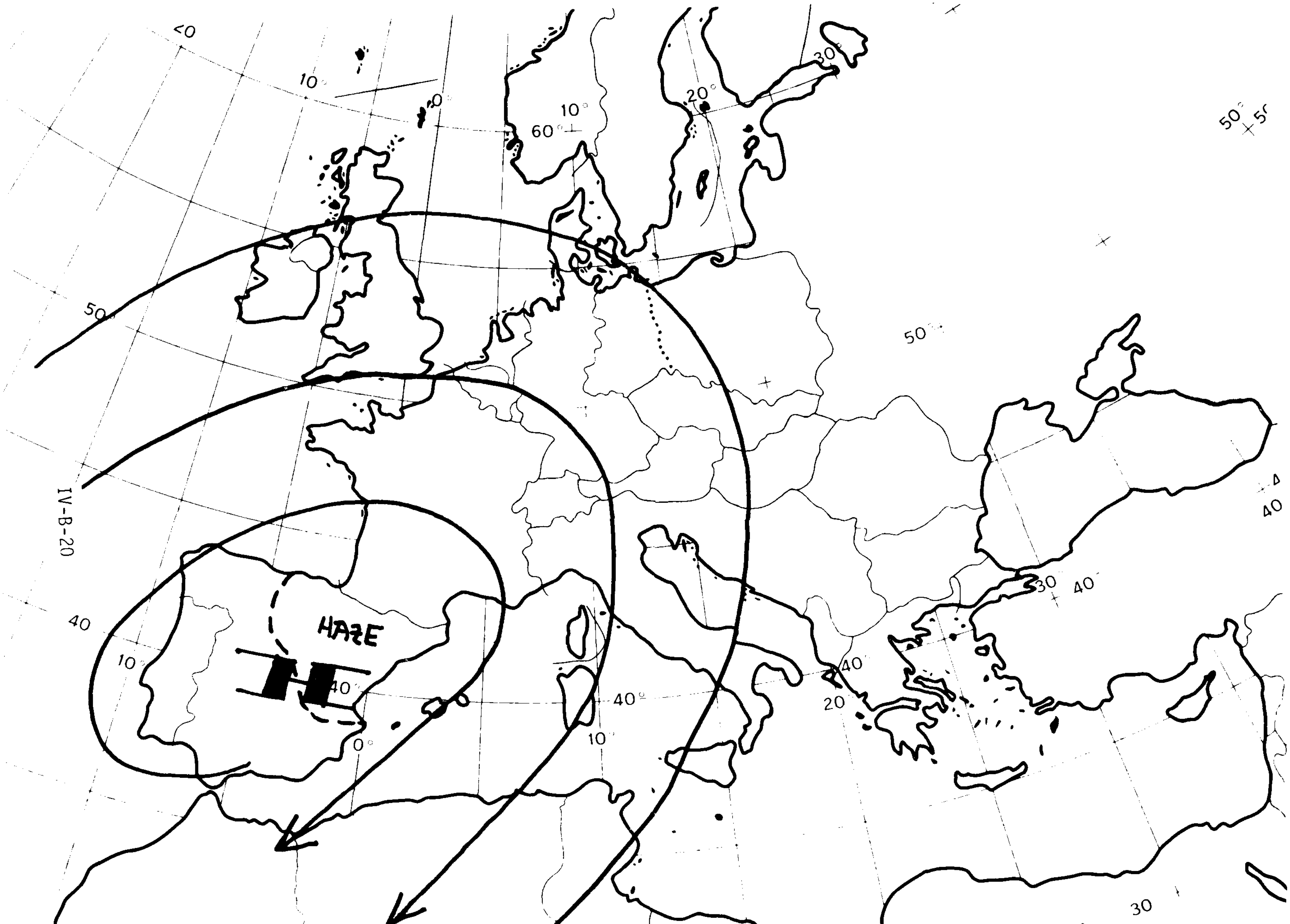


FIGURE 5 (HAZE) MAJOR Hi OVR SPAIN

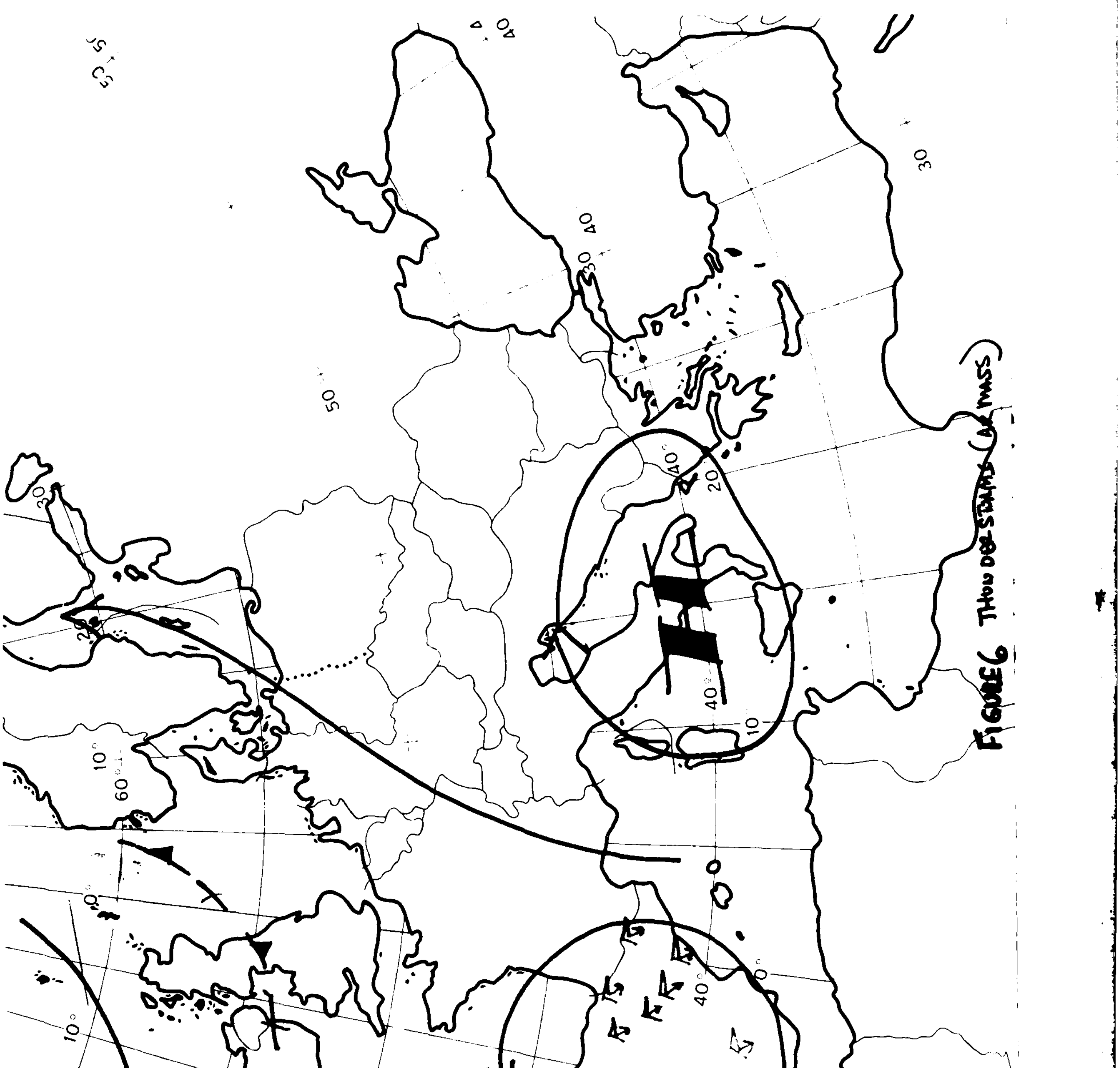


FIGURE 6 THUNDERSTORMS (AIR MASS)

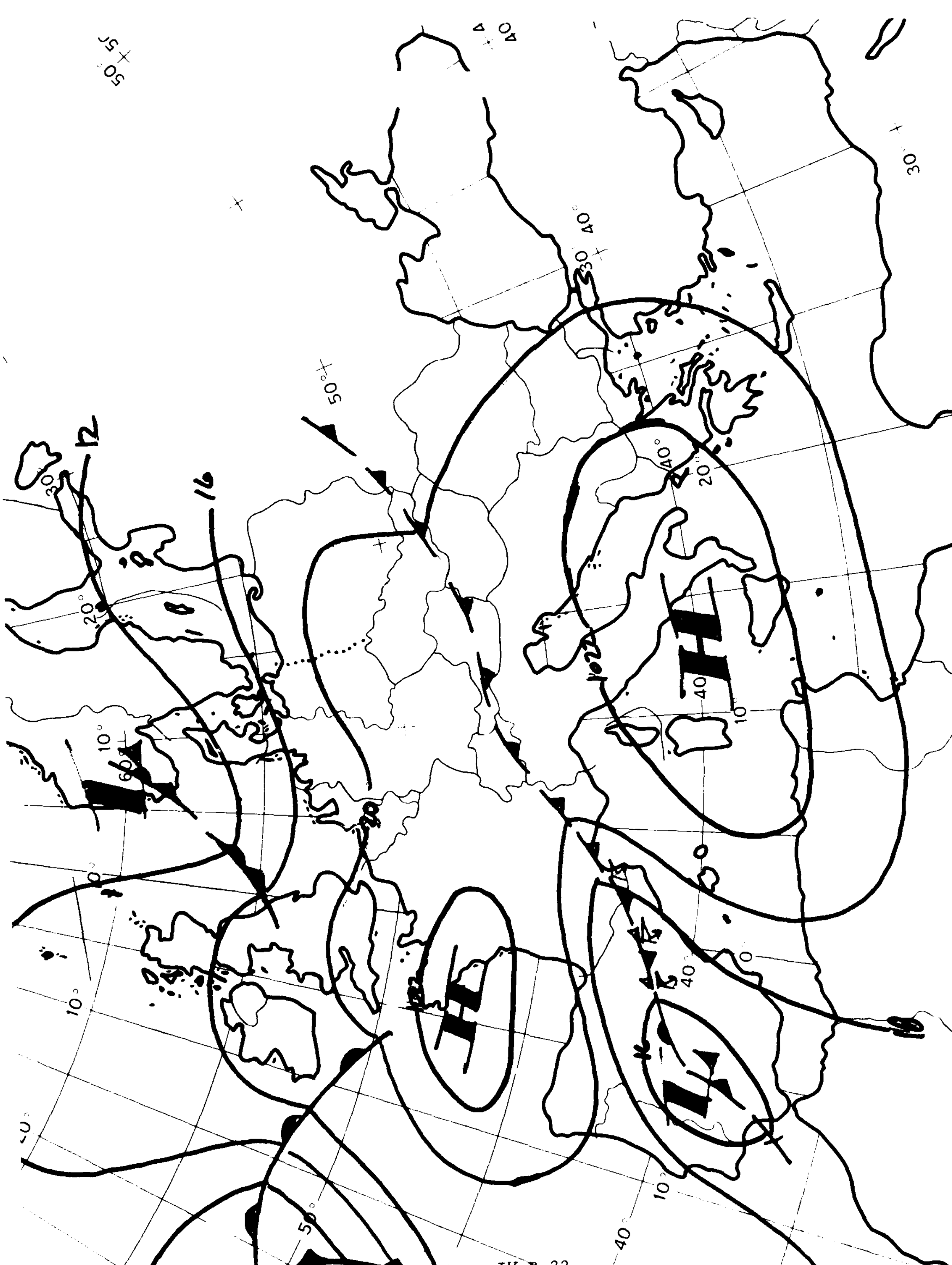


FIGURE 6a (FRONTAL THUNDERSTORMS)

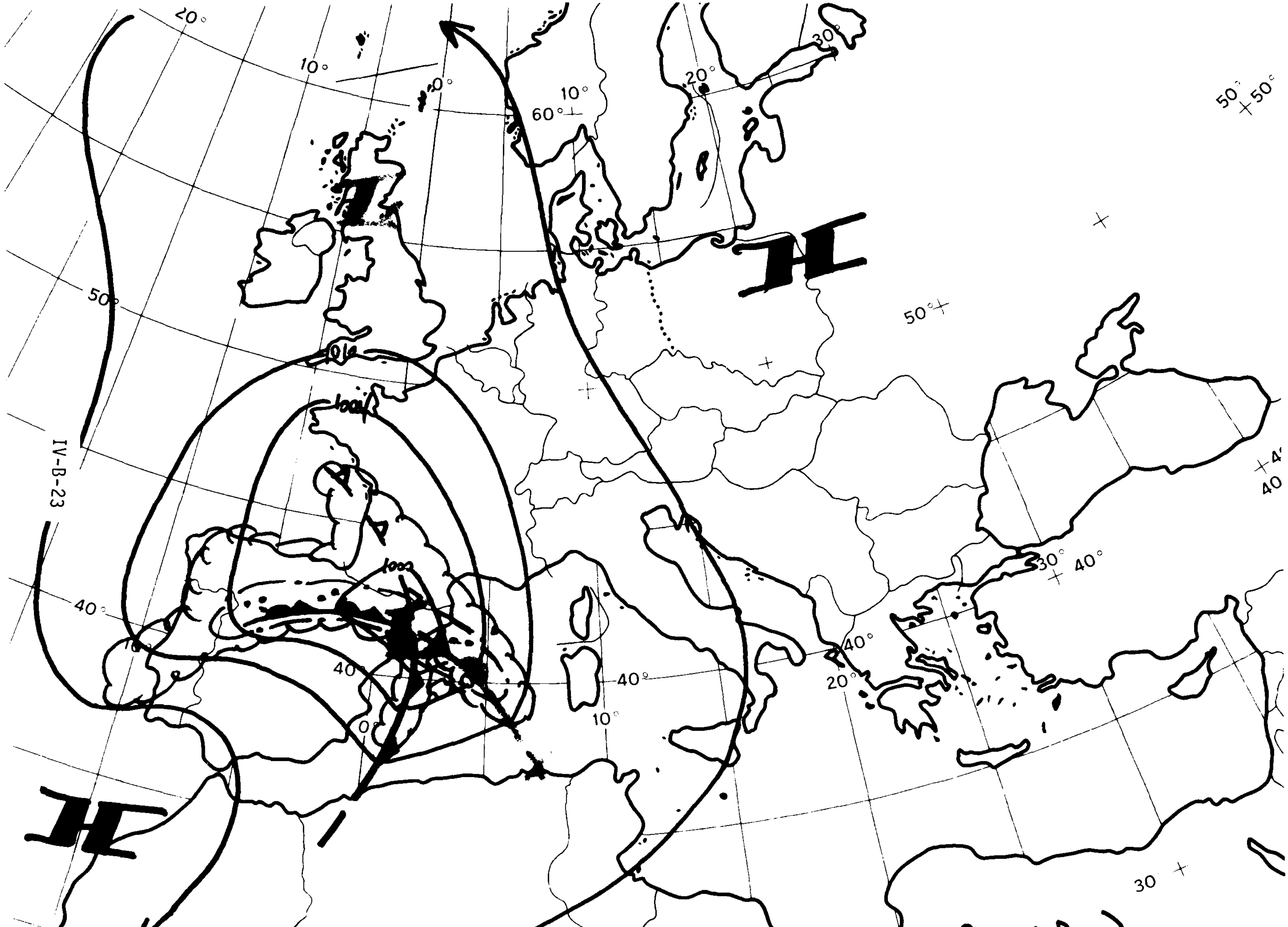


FIGURE 7 (LIGHT-MOD CONTINUOUS RA UNTIL FROPA)

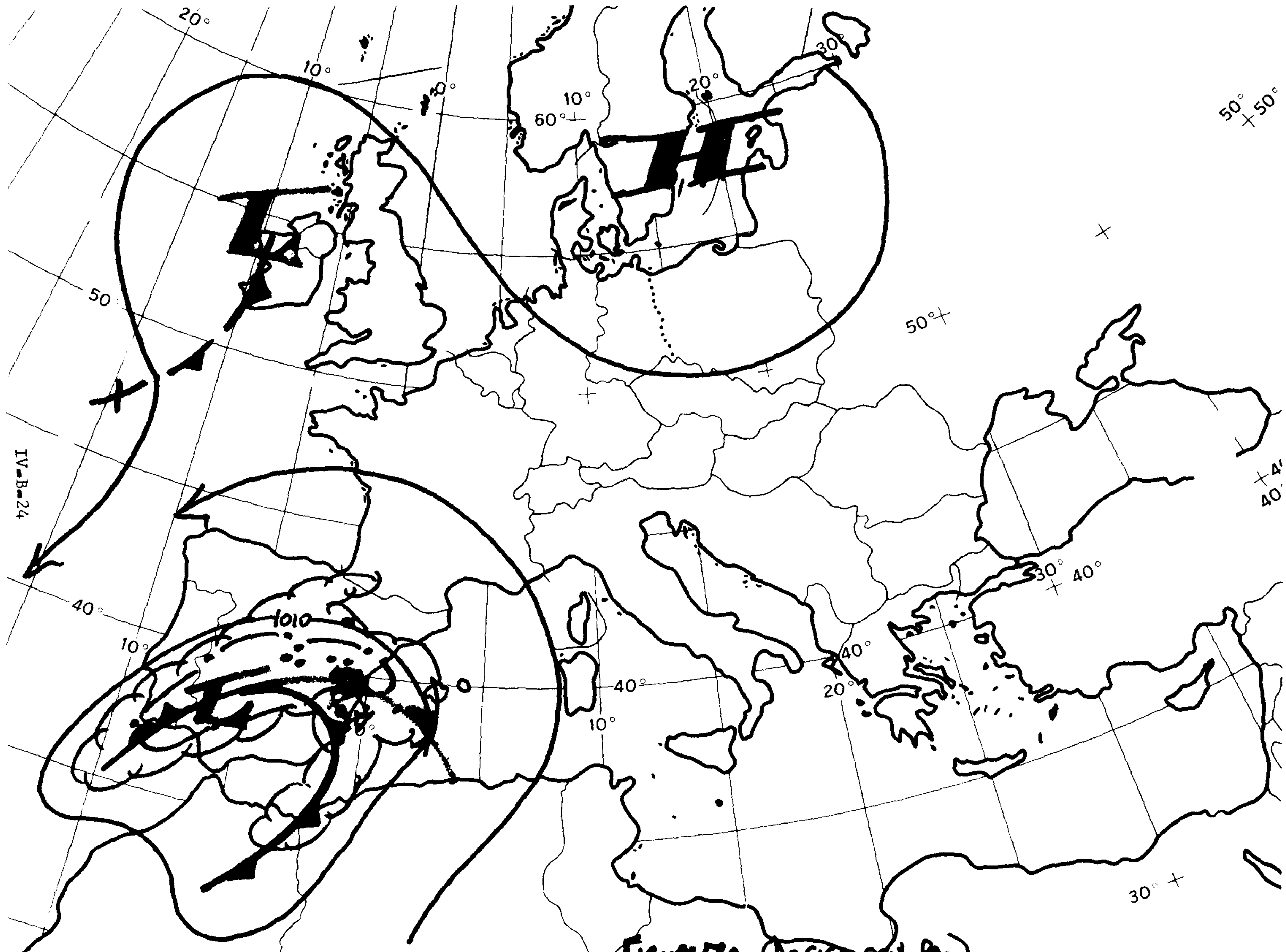


FIGURE 7A (As CIGS [illegible])

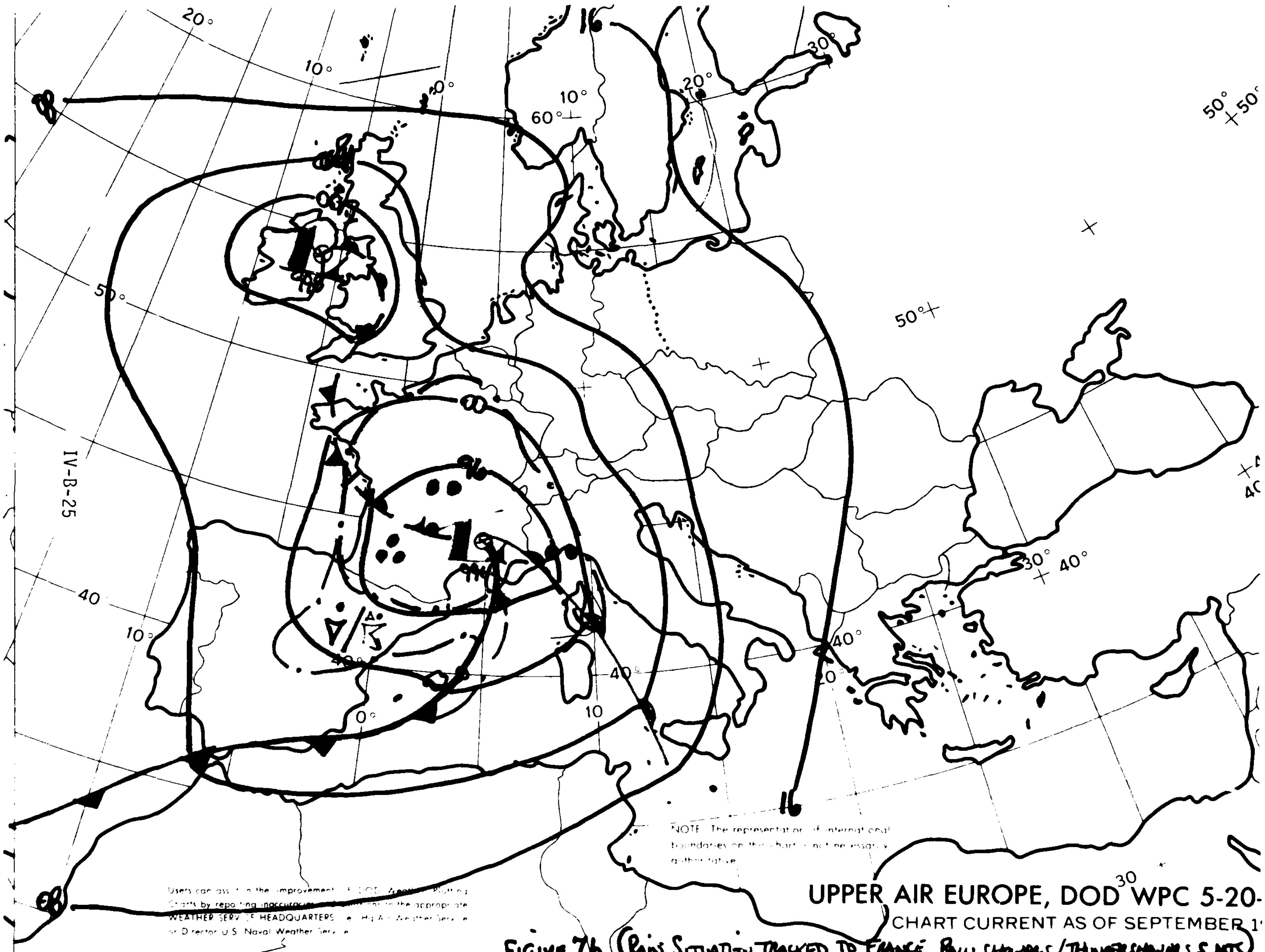


FIGURE 7b (PARIS SITUATION TRACKED TO FRANCE RAIN SHOWERS/THUNDERSHOWERS S. MTS)

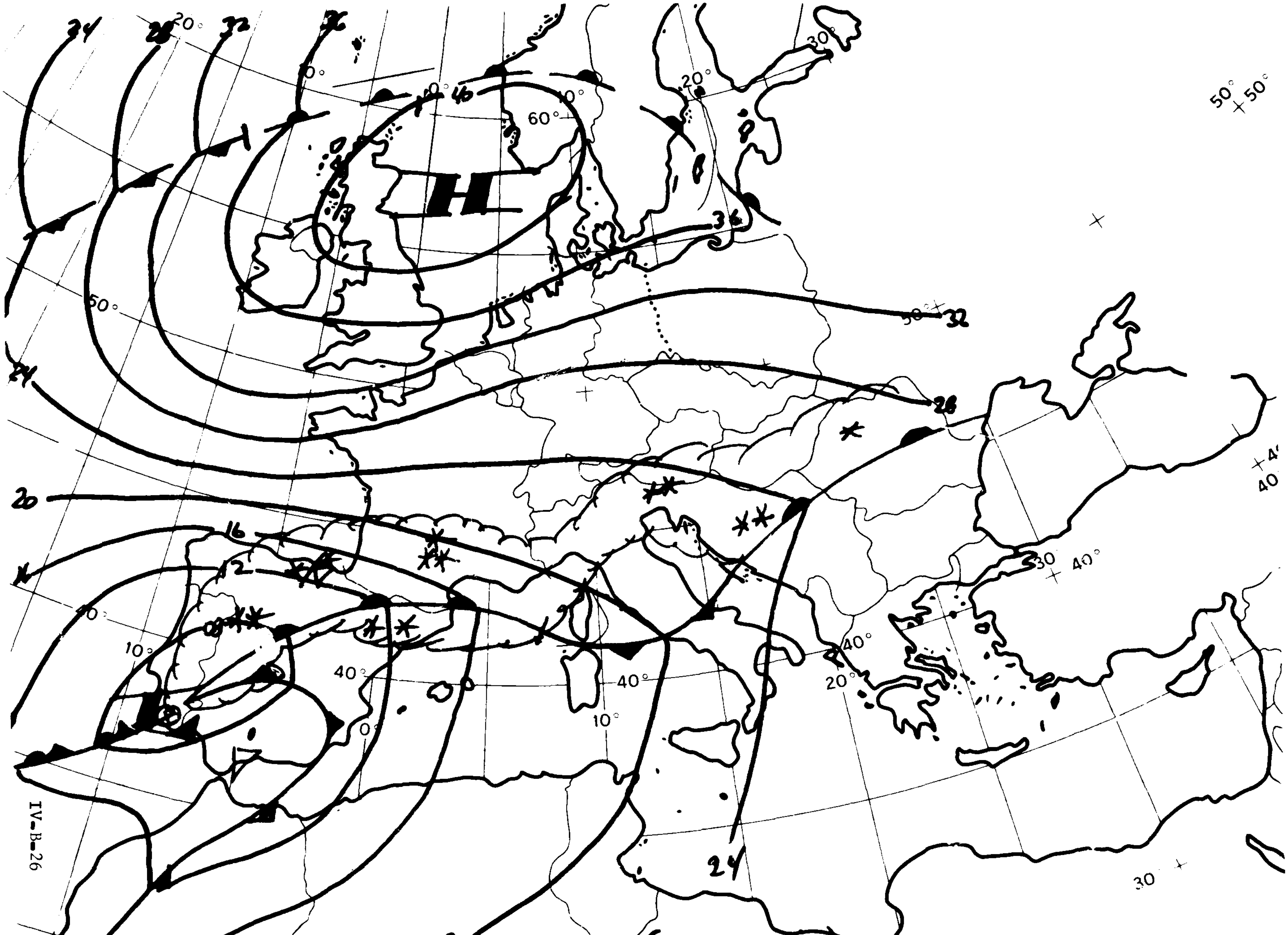


FIGURE 8 (SNOW SITUATION)

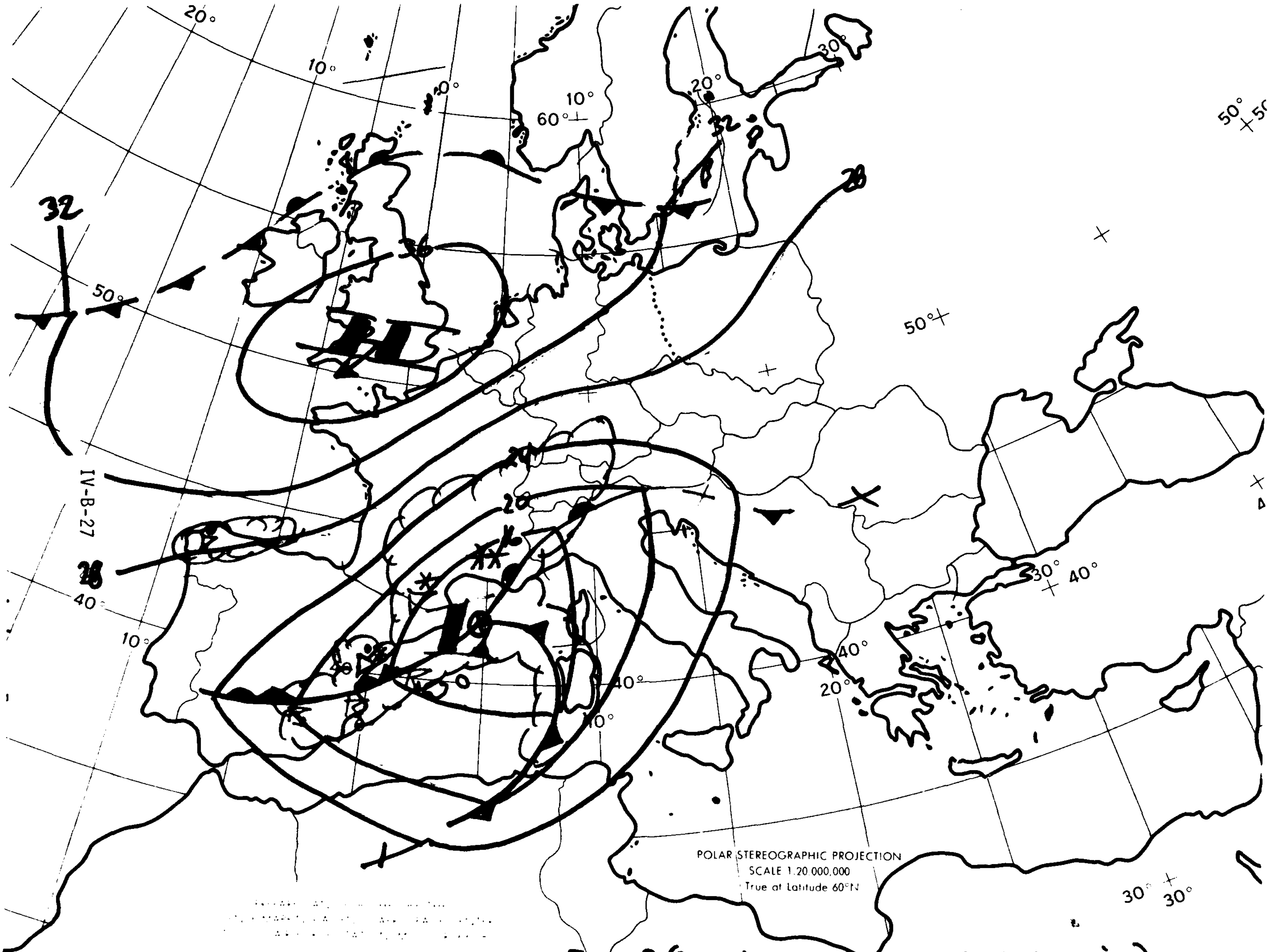
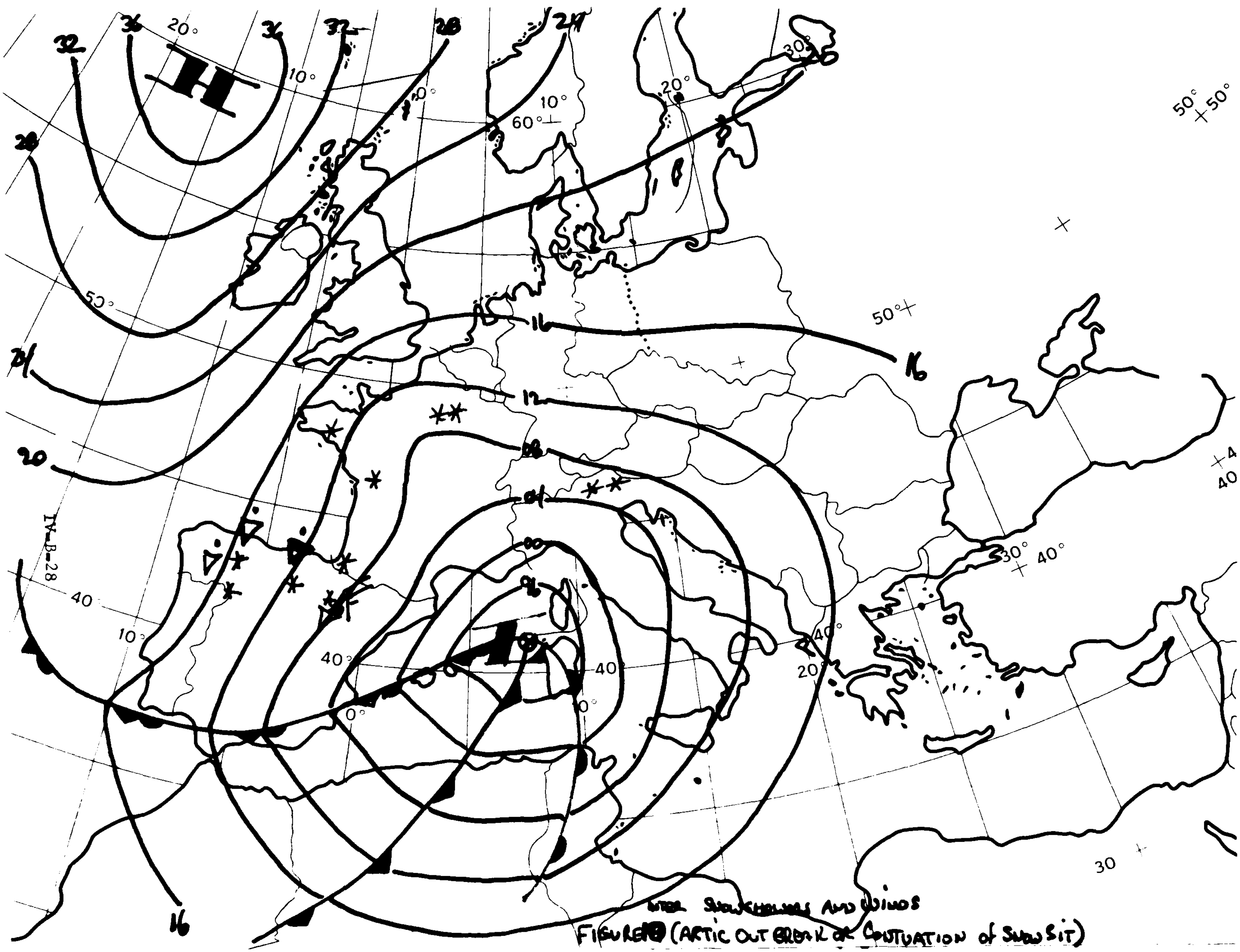


FIGURE 9 (CONT FIG 8, INTER SNOW SHOWERS/MIXED AND WINDS)



Later snowshowers and winds
FIGURE (ARTIC OUT BREAK or CONTUATION of SNOW SIT)

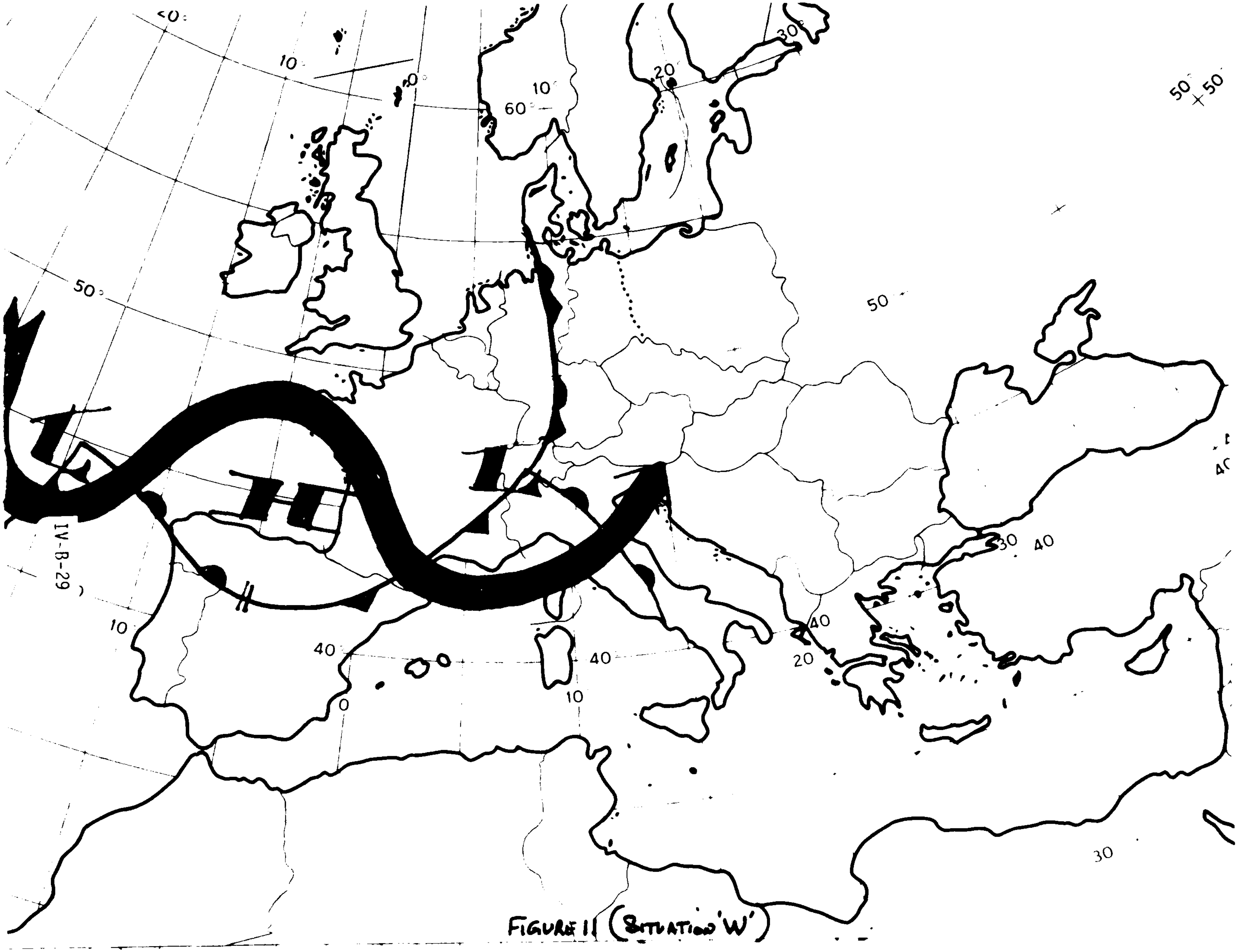


FIGURE 11 (SITUATION 'W')

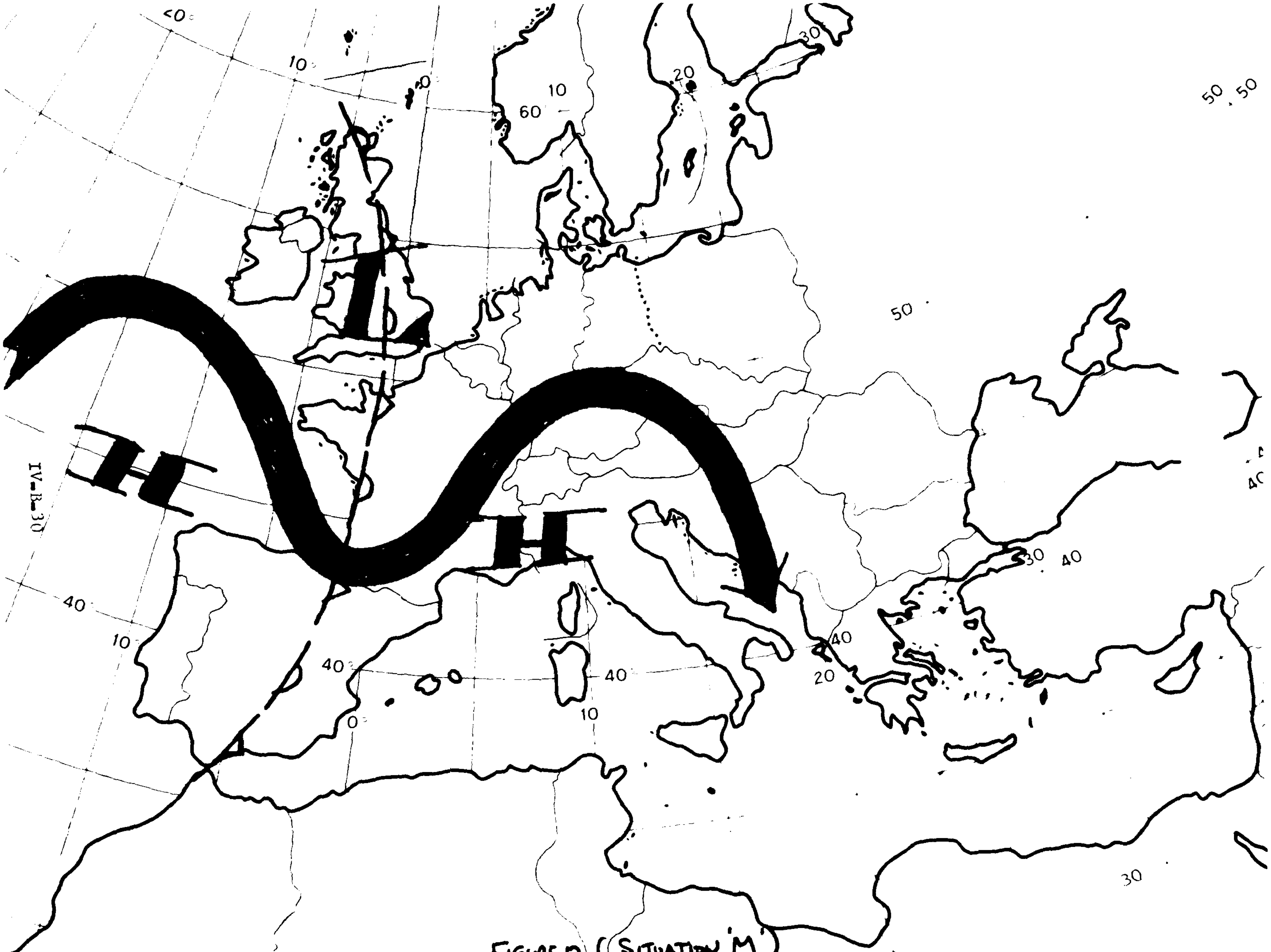


FIGURE 12 (SITUATION 'M')

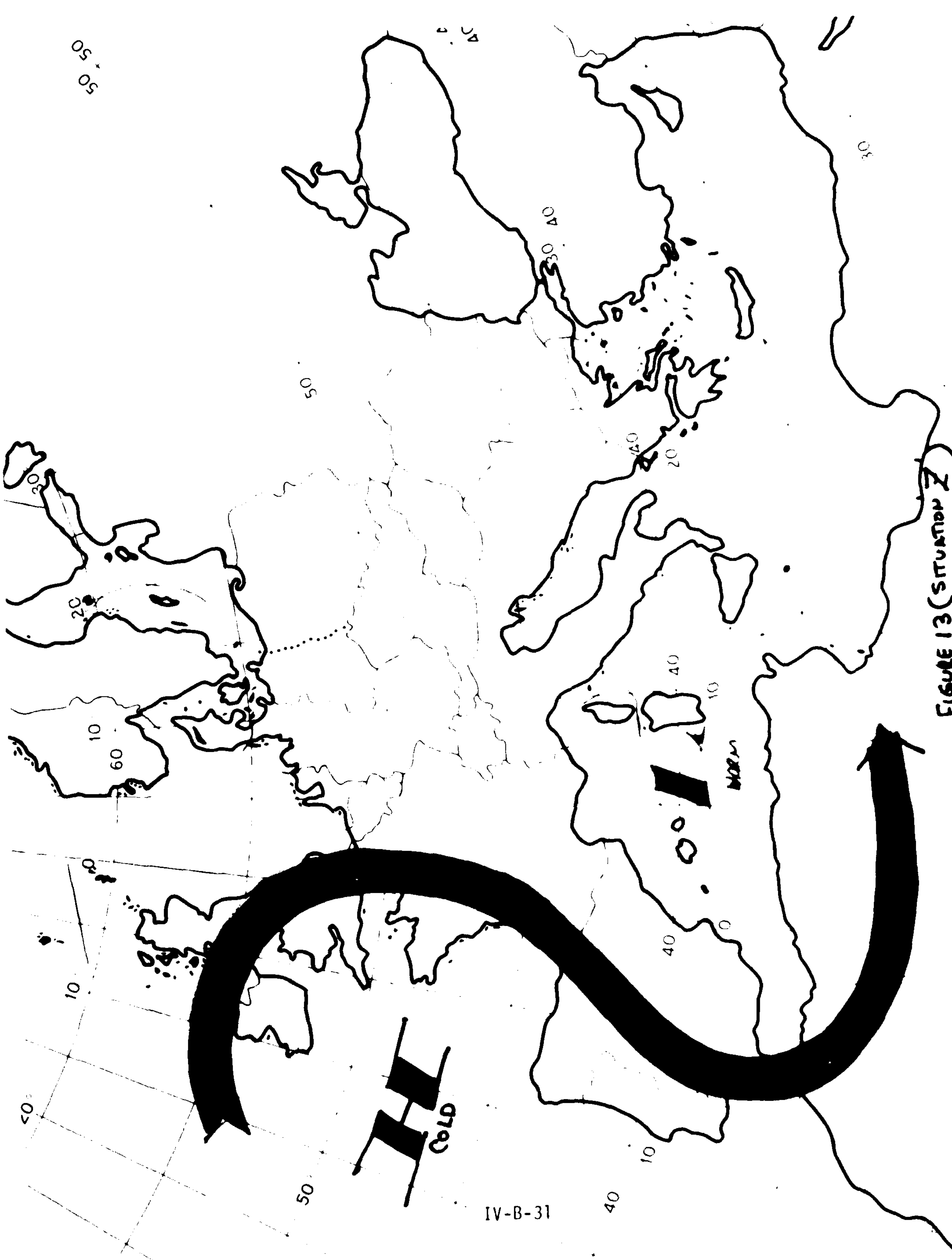


FIGURE 13 (SITUATION I)

FIGURE 14 (SITUATION 'S')

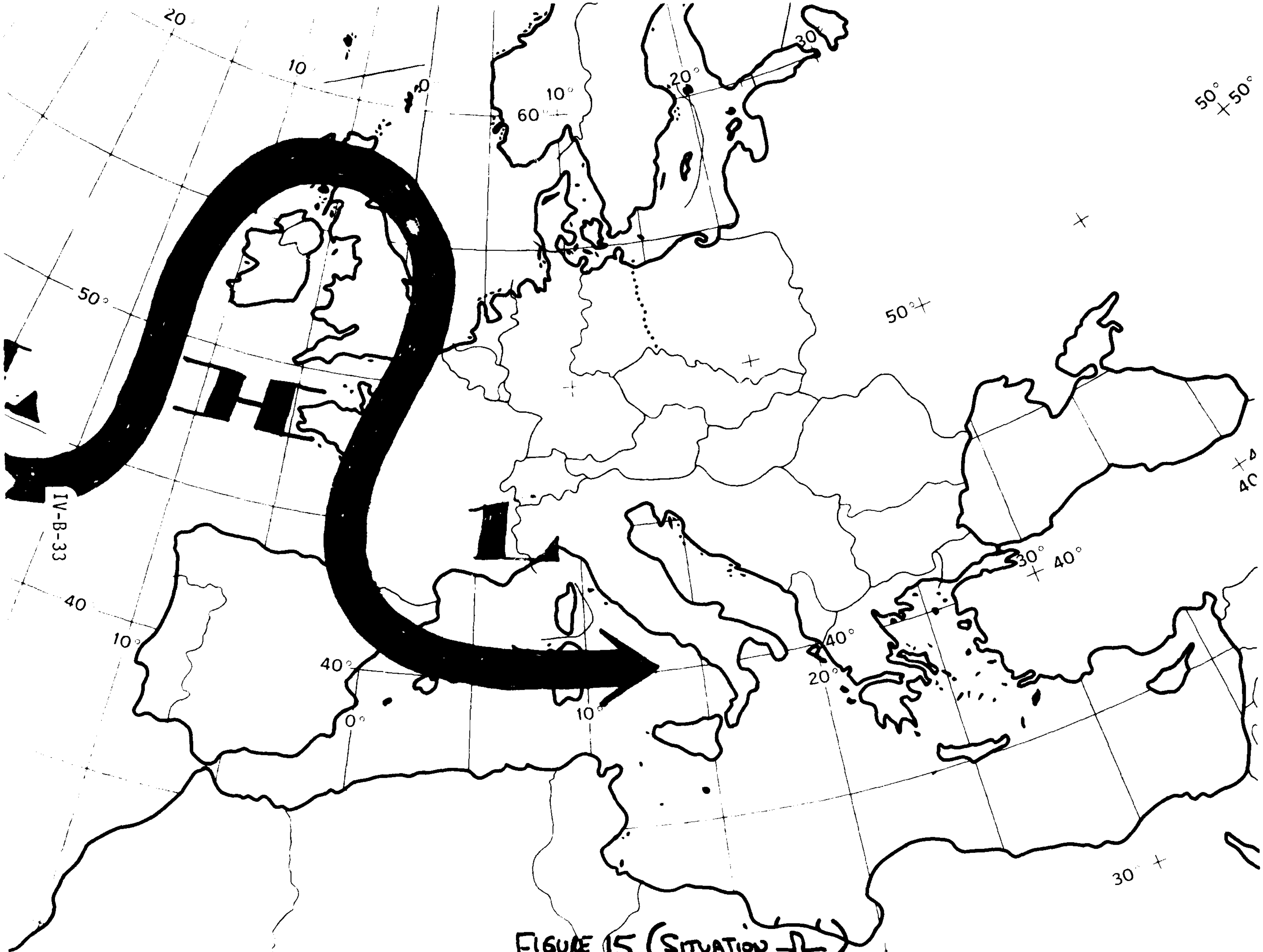


FIGURE 15 (SITUATION Ω)

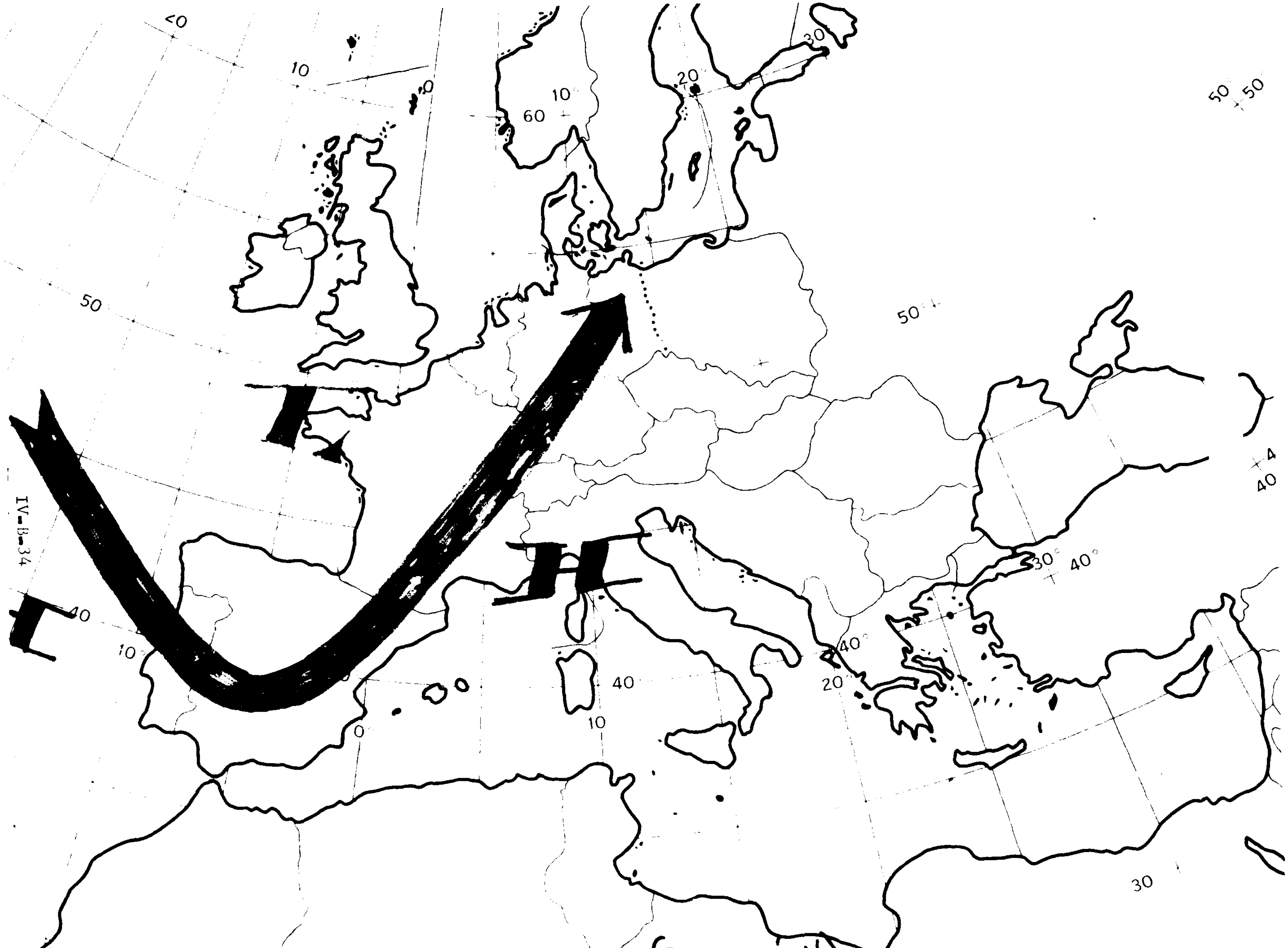
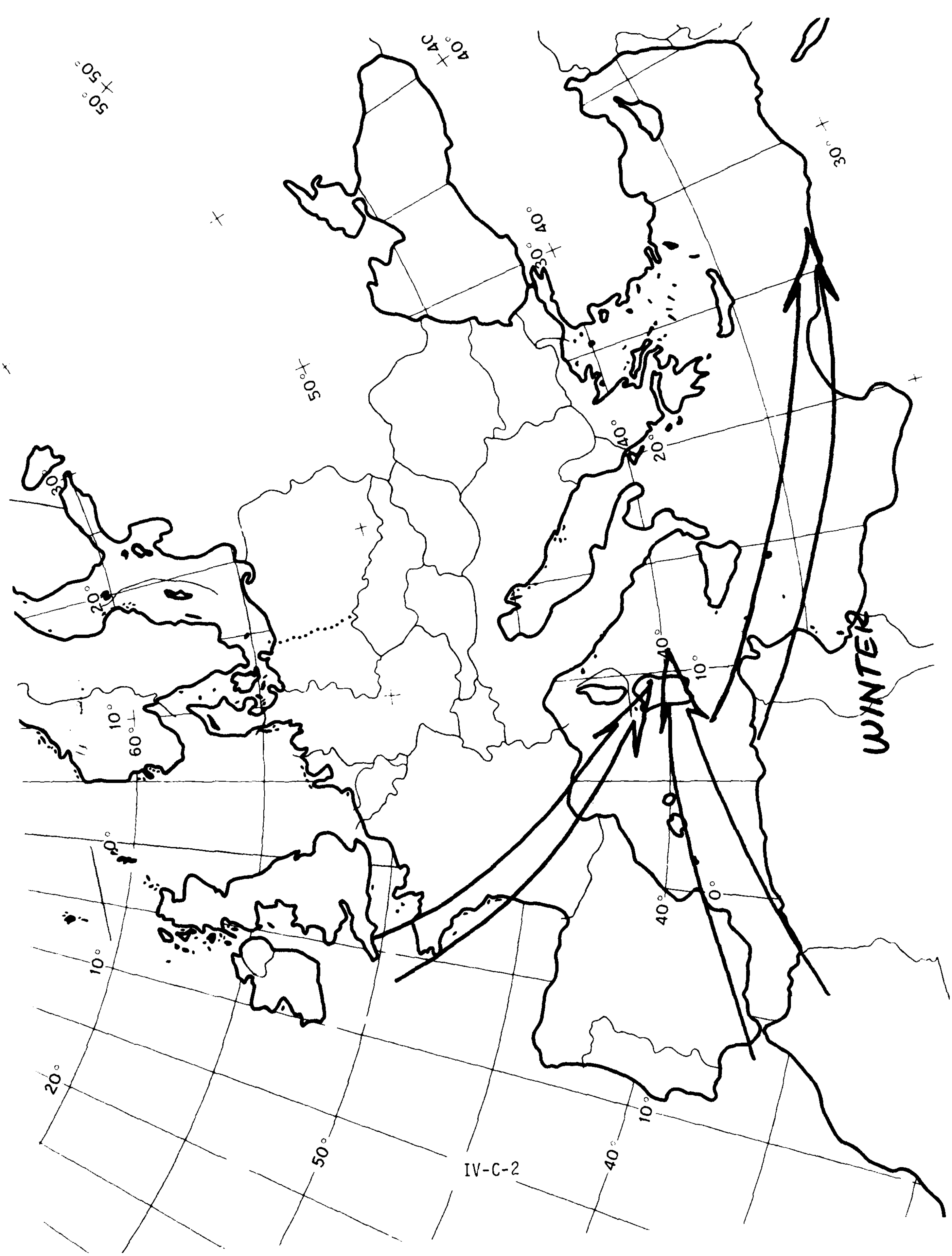
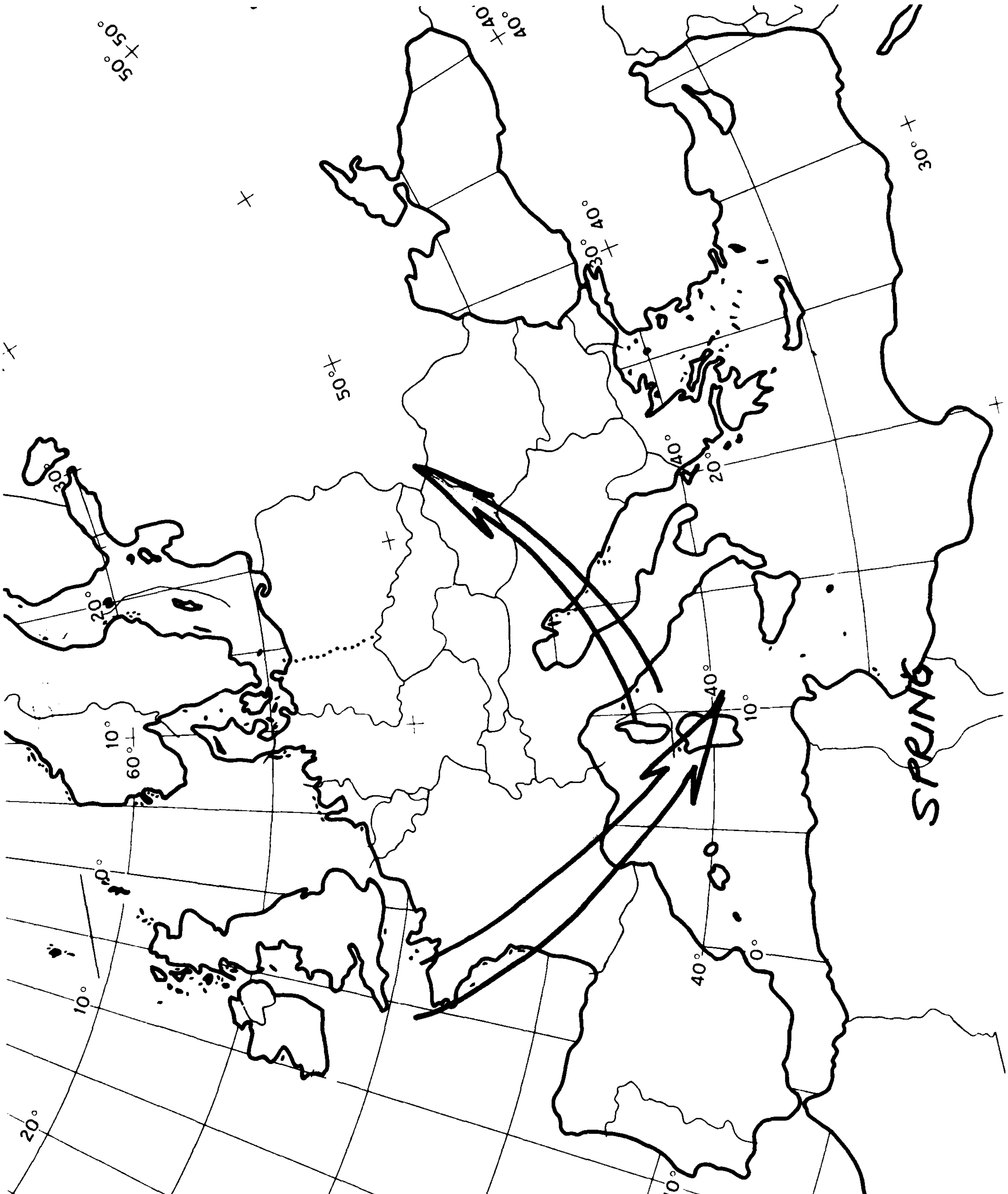


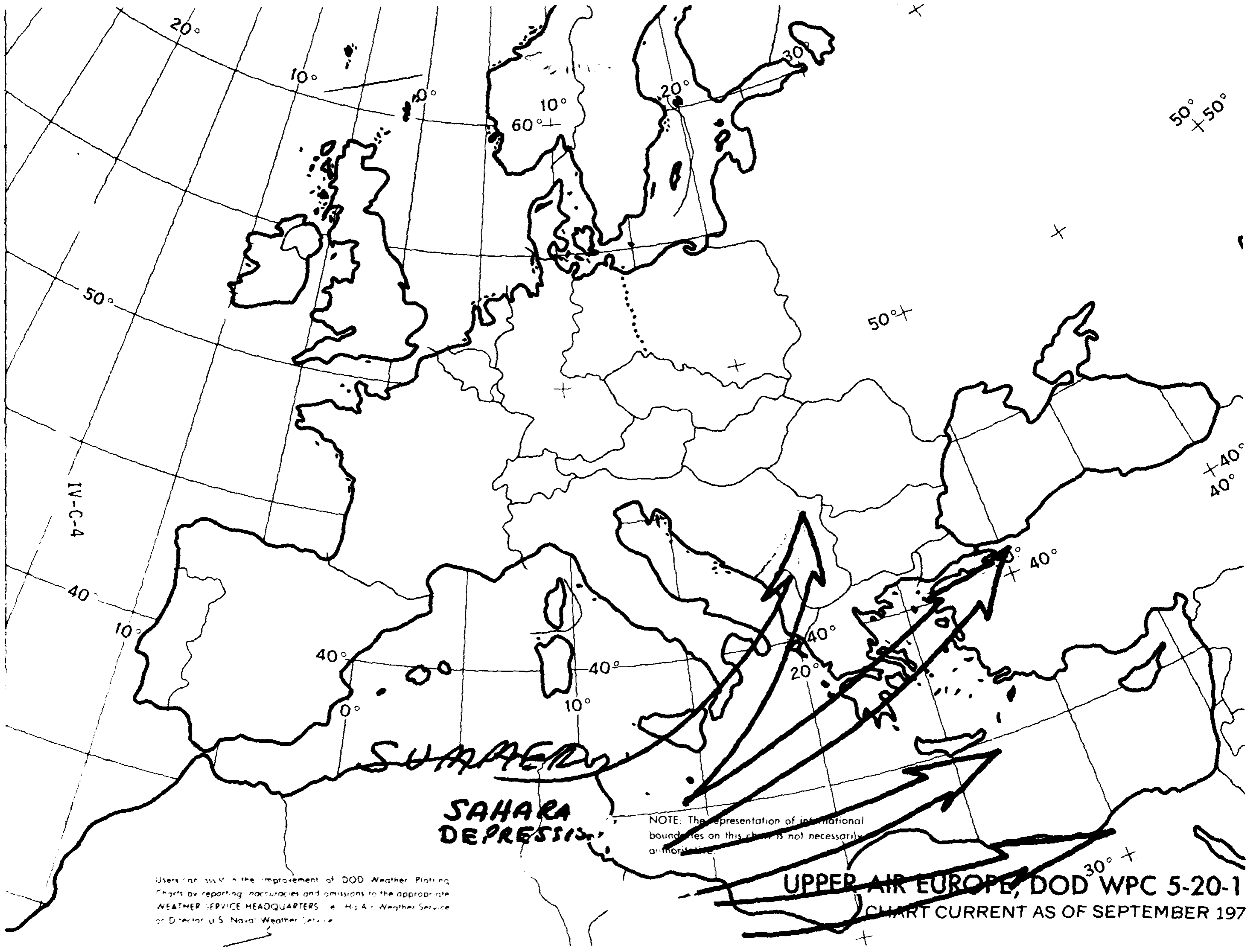
FIGURE 16 (SITUATION 'V')

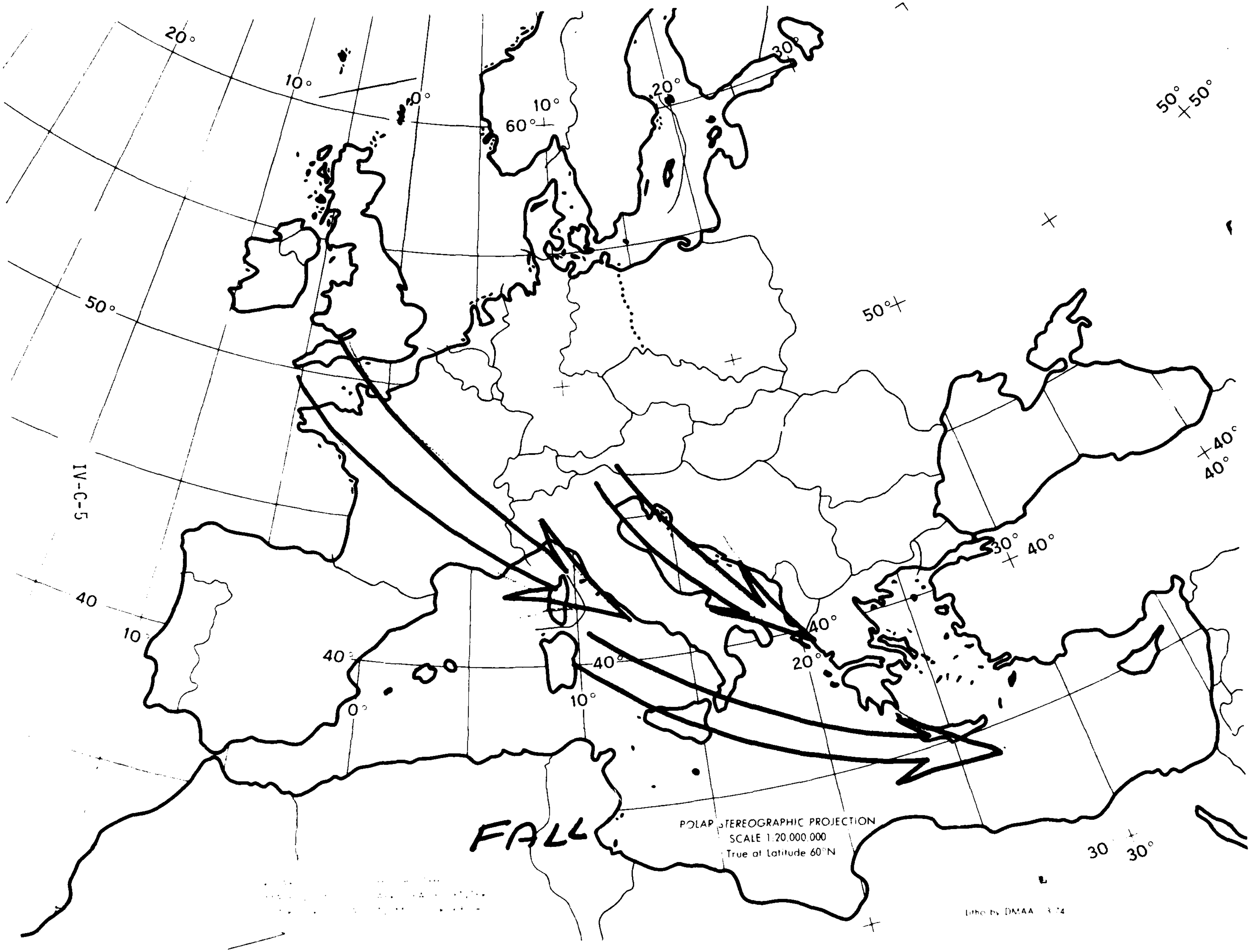
SEASONAL STORM TRACKS

These tracks were extracted from ENVPREDRSCHFAC Technical Paper 5-75, Handbook for Forecasters in the Mediterranean, published in November 1975.


WINTER


SPRING


SUMMER
SAHARA DEPRESSI...
NOTE: The representation of international boundaries on this chart is not necessarily authoritative.
Users can assist in the improvement of DOD Weather Plotting Charts by reporting inaccuracies and omissions to the appropriate WEATHER SERVICE HEADQUARTERS
UPPER AIR EUROPE, DOD WPC 5-20-1
CHART CURRENT AS OF SEPTEMBER 197
IV-C-4


FALL
POLAR STEREOGRAPHIC PROJECTION
SCALE 1:20,000,000
True at Latitude 60°N
Litho by DMAA

DATE
FILMED
-8